Report of the Chief

of the

Bureau of Entomology

and Plant Quarantine

1949

UNITED STATES DEPARTMENT OF AGRICULTURE

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LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1949.

DR. P. V. CARDON,
Agricultural Research Administrator.

DEAR DR. CARDON: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1949.

Sincerely yours,

P. N. ANNAND, *Chief.*

CONTENTS

	Page
Headlines for the year	1
Insects affecting man	2
House flies develop resistance to DDT	2
Aerial applications of DDT kill mosquitoes and black flies	3
New chlorinated hydrocarbons as effective as DDT against flies and mosquitoes	3
Fabrics protected against damage by insects	3
Insects affecting livestock	4
Toxicology of insecticides when applied to livestock	4
Safer insecticides replace DDT for use on dairy farms	4
Effect of insecticides on livestock studied	5
Storage of insecticides in fatty tissues of cattle	5
New insecticides tested against livestock pests	6
Forest insects	7
Outbreaks of pine bark beetles in western forests being controlled	7
Bark beetles controlled through sanitation-salvage cuttings	7
Mountain home owners of southern California combat bark beetles	8
Ips infestations affected by climate	8
Aerial spraying controls spruce budworms	9
Resistant strains of pines may solve weevil problem in California	9
Engelmann spruce beetle still active in Colorado	10
Research on insects affecting forest products shows progress	10
New program of forest-pest surveys organized	11
Gypsy moths	11
Cooperative programs expedite control	11
Cape Cod initiates its own spray program	12
Collection of attractant for survey traps increased	12
Active constituent of gypsy moth attractant studied	13
Preventing spread of gypsy moths through regulatory activities	13
Truck-crop and garden insects	14
Organic phosphorus compounds outstanding against greenhouse pests	14
Parathion effective against green peach aphid on tobacco	15
Effect of insecticides on the yield and quality of tobacco tested	15
New fumigant for cigarette beetle in stored tobacco	16
Control of aphids on potatoes improved	16
DDT gives best residual action on pea aphid	16
New insecticides effective against aphids on cole crops	16
Cost of controlling cabbage caterpillars reduced	17
Insecticides kill melonworms and pickleworms on cucumbers	17
Remedy sought for serpentine leaf miner	17
Soil insecticides for wireworms evaluated	17
Onion thrips controlled with several new insecticides	18
New insecticides kill insects affecting sugar-beet seed	18
Sweetpotatoes protected from weevil damage	18
Nematodes infesting potatoes	19
Golden nematode not found outside of Long Island	19
Potato rot nematode limited to small area in Idaho	20
Fruit and nut insects	21
Phony peach vectors incriminated	21
Tests of new insecticides against fruit and nut insects continued	21
Apple insects	21
Pear psylla	22
Insect pests of stone fruits	23
Pecan insects	24
Citrus pests	24
Pineapple mealybug	25
Grape insects	25

Fruit and nut insects—Continued Page
Parathion promising for control of scale insects 25
Hall scale eradication 26
Studies on vectors of stone-fruit viruses begun 27
Comstock mealybug at low ebb 27
Steps taken to combat oriental fruit fly menace 28
Sprays and parasites used against the citrus blackfly in Mexico 28
Treatments to kill fruit flies permit movement under quarantine 29
New laboratory for study of European chafer 29
Parasites of fruit insects exported 30
Japanese beetles 30
DDT reduces isolated beetle infestation 30
Recommended soil treatments injure few plants 30
Quarantine and control activities 31
Cotton insects 32
New insecticides effective against pests of cotton 32
Boll weevil 32
Bollworm 33
Cotton aphid 33
Pink bollworm 33
Salt-marsh caterpillar 33
Other cotton insects 34
Progress made in basic research on cotton insects 34
Pink bollworm quarantine activities 34
Results of inspection 34
Control operations 35
Regulatory operations 37
Cooperative work with Mexico 37
Cereal and forage insects 38
Grasshoppers 38
Control programs in 1948 protected extensive crop and range lands 38
1949 outbreaks fought with new baits applied by airplane 38
Chlordane and toxaphene new weapons to combat hoppers 39
Mormon cricket damage slight on crops and range 39
Chinch bugs and cutworms require little control 40
Cotton bags made insect-proof 40
European corn borer continues to spread 41
Parasites of European corn borer and sweetclover weevil imported 41
Benzene hexachloride and parathion control greenbugs 42
Toxaphene effective against meadow spittlebug 42
New insecticides control southern corn rootworm in peanuts 42
White-fringed beetles 43
Soil and foliage treatments with DDT subdue beetles 43
Effect on plants of various DDT formulations used to control white-fringed beetles 44
Chemical studies of insecticides 44
New insecticides similar to pyrethrum made synthetically 44
Chemical methods for parathion developed 45
Insecticidal amide isolated from prickly-ash 45
Diluents for insecticides sought in agricultural waste products 45
Methods of disinfesting aircraft improved 46
Work on mechanical devices for use in pest control coordinated 46
Imported beetles control Klamath weed on west coast 47
Honey bees and other pollinating insects 47
Lack of pollination a serious threat to seed production 47
Honey bees prodigiously active as clover pollinators 48
Crops compete for bees 48
Wild pollinating insects reared in artificial nests 49
Hybrid queens distributed for testing 49
New insecticides kill only field bees 49
Honey bees bred for resistance to American foulbrood 50
Sulfathiazole for treating American foulbrood in experimental stage 51
Plastic package-bee containers withstand shipping tests 51

Page

Control of plant diseases ---- 51
White pine blister rust ---- 51
Improved methods aid ribes removal ---- 51
Ribes bushes removed from 1,679,000 acres ---- 52
Rust spread in southern Applachians ---- 53
Ribes sprayed with 2,4-D formulations by helicopter ---- 53
Survey shows rust losses in western pine stands ---- 53
Barberry eradication to control stem rust ---- 54
New and uncommon races of rust found on barberry ---- 54
Stem rust light in 1948 ---- 54
Regulation of barberry planting stock strengthened ---- 55
Chemicals aid removal of barberry bushes ---- 56
Barberry varieties tested for susceptibility to stem rust ---- 56
Dutch elm disease ---- 56
Inspection for peach diseases protects industry ---- 57
Resurvey fails to reveal citrus canker in Texas ---- 57
Insect identification and classification important aids to control programs ---- 58
In-transit inspection ---- 58
Inspection service in District of Columbia ---- 58
Foreign plant quarantine activities ---- 59
Carriers and products inspected ---- 59
Plants and pests intercepted ---- 61
Treatment of imported plant material ---- 62
Certification for export ---- 62
Organization of Bureau ---- 63

REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, AGRICULTURAL RESEARCH ADMINISTRATION, 1949

HEADLINES FOR THE YEAR

The Bureau's war against insect pests and plant diseases progressed during the year. New insecticides and new methods of applying insecticides were developed. Improvements in equipment, particularly for the utilization of aircraft in large-scale operations, greatly aided control programs. New treatments were authorized to expedite the movement of plant products under quarantine regulations, and more adequate protection against foreign pests was provided through a revision of regulations governing the importation of plant material.

Compounds similar to the insecticidal principle of pyrethrum flowers were synthesized by Bureau chemists, and some of them were more toxic to flies than pyrethrum. If the commercial production of any of these compounds proves successful, it will give us, through chemistry, a substitute for a plant material of wide importance in insect control and for which we have been entirely dependent on foreign sources.

Two new insecticides, methoxychlor and lindane, were recommended for fly control in dairy barns and other buildings where milk is handled, to meet the Food and Drug Administration's objection to the use of DDT for this purpose.

Several new organic phosphorus compounds were found to be even more effective than tetraethyl pyrophosphate when used in aerosols to combat aphids and mites in greenhouses.

New baits and new equipment for distributing them were used in 1949 to combat the widespread grasshopper outbreaks in the Middle West and the West.

New methods and equipment for disinfesting aircraft were developed and tested in planes operating out of Honolulu.

A method was devised for treating cotton bags to keep insects out of flour and other cereal products packed in them.

The regulations issued under the nursery stock, plants, and seed quarantine were revised to provide for the growing of certain plants under observation in post-entry quarantine long enough to determine their apparent freedom from pests not discernible by inspection.

Before an insecticide is recommended for use against any insect pest, its effect on the treated plants or animals and on the health of the consumer, as well as the hazards of handling, should be determined.

In view of the toxicity of residues from certain of the new insecticides, special toxicological studies are being conducted in cooperation with other Bureaus in the Department of Agriculture, the Food and Drug Administration of the Federal Security Agency, and several State agricultural experiment stations.

Measures to keep the oriental fruit fly from reaching continental United States were strengthened through stricter quarantine regulations, including disinfestation of aircraft, and further study of means of controlling the pest in Hawaii. Walter Carter, of the Pineapple Research Institute of Honolulu, was appointed to organize and direct an expanded research program to combat this fly.

A new Division of Golden Nematode Control was established to cooperate with State and local agencies in efforts to control and prevent further spread of this important pest of potatoes. Harry L. Smith, leader of the golden nematode project for the past year, heads this new Division, with headquarters at Hicksville, N. Y.

Ralph A. Sheals, formerly in charge of the Bureau's Division of Gypsy Moth Control, was appointed assistant to W. L. Popham, assistant chief of the Bureau in charge of control operations.

INSECTS AFFECTING MAN

The research on insects affecting man is supported largely by funds transferred from the National Military Establishment, although certain aspects of the work are closely coordinated with related activities under regular Bureau appropriations. The investigations for the armed services are being conducted in cooperation with the offices of the Surgeon General, the Quartermaster General, and the Chief of Engineers in the Department of the Army, and of the Surgeon General in the Department of the Navy, and with the Department of the Air Force.

House Flies Develop Resistance to DDT

House flies in some areas have developed a marked resistance to DDT. During the summer of 1948 reports of the failure of this insecticide to provide the usual high degree of fly control were received from many parts of the United States. Investigations showed that improper application of DDT and failure to prevent excessive fly breeding were important factors responsible for these failures. However, tests with flies collected from certain areas in Florida, Georgia, Texas, and California showed some of them to be 20 to 50 times as resistant as nonresistant laboratory strains.

That house flies can develop resistance to the point of practical immunity has been demonstrated in laboratory experiments. Successive generations of flies that survived exposure to DDT were reared until a strain was developed that was about 250 times as resistant as nonresistant strains. This selection required 3 years and 60 generations, in each of which about 90 percent of the flies were killed by increasing dosages or exposures.

In view of the marked resistance of some fly strains to DDT, several possible substitute insecticides were investigated. Methoxychlor,

chlordane, and gamma benzene hexachloride all showed promise, although certain strains of flies highly resistant to DDT also showed some resistance to these insecticides.

Aerial Applications of DDT Kill Mosquitoes and Black Flies

Aerial applications of DDT gave excellent control of mosquitoes and black flies. In Alaska several areas comprising up to 30,000 acres were treated at the rate of 0.1 pound of DDT per acre. Both larvae and adults of *Aedes* and *Culiseta* mosquitoes were killed. Mosquitoes in Alaska are unusually strong fliers, however, and several sprayings during the season were necessary to give protection against those flying in from untreated areas. Black fly larvae in streams were also killed by this treatment. A single passage of a C–47 airplane spraying an 800-foot swath across a stream gave complete control of these larvae for a distance of 2½ miles below the place of application.

Experiments were continued with applications of DDT to mosquito-breeding places before snowfall. In Oregon good control of mosquitoes was obtained with 0.5 pound of DDT applied at this time. In Arctic areas treatments before snowfall and applications to the snow killed larvae hatching in the spring, but results were erratic when dosages less than 0.25 to 0.5 pound per acre were used. In comparative tests more dependable control at lower dosages was obtained when applications were made after the eggs had hatched. However, repeated applications of DDT against adults over mosquito-breeding areas left sufficient deposit to cause a marked reduction of larvae the following season.

Observations in Pennsylvania after aerial spraying with DDT for gypsy moth control showed that black flies were killed by the treatment.

New Chlorinated Hydrocarbons as Effective as DDT Against Flies and Mosquitoes

Several new chlorinated hydrocarbon insecticides have been tested in the laboratory to compare their effectiveness against mosquitoes and house flies with that of DDT. Heptachlor and a compound known as 118 were about as effective as DDT against larvae of the common malaria mosquito and several species of *Culex* and *Aedes*, but less effective against adults of the yellow-fever mosquito. Another compound, known as 497, was two or three times as toxic as DDT to both larvae and adults of all these species. When tested against house flies, all three of these compounds were much more toxic than DDT when employed as space sprays, and one of them (497) also showed considerable residual effectiveness. Further work is under way with these materials.

FABRICS PROTECTED AGAINST DAMAGE BY INSECTS

DDT has been found to give excellent protection to woolen fabrics and certain other animal products, such as feathers and bristles, against damage by insects. Woolen cloth impregnated with as little as 0.25

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percent of DDT (by weight) has remained undamaged after 18 months' exposure to heavy infestations of fabric insects. The first year's tests conducted for the Army indicate that this insecticide gives better protection to stored woolen cloth than the naphthalene treatment now being used by the armed forces. If future tests confirm these results and DDT is substituted for naphthalene, much less cloth will be lost through insect damage, at a tremendous saving in cost of the treatment.

Although DDT gives the best protection to cloth from damage, chlordane and benzene hexachloride are more effective in killing fabric insects. Although generally less effective, methoxychlor, TDE, and toxaphene also show considerable promise.

INSECTS AFFECTING LIVESTOCK

Toxicology of Insecticides When Applied to Livestock

Investigations on various aspects of the toxicology of insecticides when applied to livestock were continued with funds authorized under the Research and Marketing Act of 1946. This work was done in cooperation with the Bureau of Animal Industry, the Bureau of Dairy Industry, the Texas Agricultural Experiment Station, the Food and Drug Administration, and the insecticide industry. Certain phases of this cooperative work are also discussed in the current Annual Report of the Chief of the Bureau of Animal Industry.

Safer insecticides replace DDT for use on dairy farms

This Bureau has changed its recommendations for the control of insects on milk cows and in dairy barns. This action was taken as a precautionary measure, because in the spring of 1949 the Food and Drug Administration announced that the presence of any amount of DDT in milk would be contrary to the Food, Drug, and Cosmetic Act. Studies by this Bureau in cooperation with the Bureau of Animal Industry, the Bureau of Dairy Industry, and the Texas Agricultural Experiment Station have shown that small quantities of DDT appear in milk of cows that have been treated with this insecticide and can sometimes be detected in milk following its ordinary use in dairy barns for fly control.

The Bureau recommends methoxychlor and pyrethrum insecticides, particularly a mixture of pyrethrum with piperonyl butoxide, for application to dairy animals. Methoxychlor is more effective and economical for controlling horn flies and lice, but the pyrethrum insecticides appear to give better protection against attack by stable flies and horse flies.

Methoxychlor and lindane (benzene hexachloride containing at least 99 percent of the gamma isomer) are suggested as residual sprays, and pyrethrum and an organic thiocyanate as space sprays for fly control in dairy barns and other buildings where milk is processed. Experiments showed that methoxychlor was usually effective against house flies for 1 to 2 months when applied at the rate of 200 milligrams per square foot. In some areas, however, flies that had developed a marked resistance to DDT were also more difficult to control with

methoxychlor. Sprays containing gamma benzene hexachloride applied at 25 and 50 milligrams per square foot also gave good control for 2 to 6 weeks. However, lindane is not recommended for use on milk cows, and neither methoxychlor nor lindane should be applied to forage that is to be fed to dairy cows or to animals being fattened for slaughter.

The Food and Drug Administration has stated that these new materials would not be objectionable from a health standpoint if used according to recommendations.

Recommendations for the use of DDT to control insects on other livestock, including beef cattle, have not been changed.

Effect of insecticides on livestock studied

The toxicity of various insecticides and insecticidal formulations when applied to livestock was also studied. These studies included both acute toxicity resulting from single treatments and the possible chronic effects due to repeated applications for insect control.

Young calves were found to be much more susceptible to acute poisoning than older cattle. However, little difference in susceptibility was noted between the young and old of swine, sheep, or goats. Single treatments with spray containing 1 percent of toxaphene or chlordane caused death or toxic symptoms in a small percentage of calves less than 6 weeks old. Benzene hexachloride at concentrations of the gamma isomer as low as 0.05 percent also affected some calves. Cattle a year or older tolerated at least four times the concentrations of these insecticides. Neither calves nor mature cattle showed toxic symptoms when treated with DDT, methoxychlor, or TDE in wettable-powder sprays containing 8 percent of the insecticide.

To determine the effect on animals treated repeatedly with insecticides, several young steers and heifers 6 to 9 months old were sprayed, at intervals of 2 weeks, with emulsions containing 0.5 percent of toxaphene or chlordane or sufficient technical benzene hexachloride to give 0.025 percent of the gamma isomer. After 12 applications all the treated animals showed gains in weight at least equal to those in untreated check animals. These preliminary studies indicate that none of these insecticides when used for insect control are likely to have any adverse effect on the growth of cattle.

Storage of insecticides in fatty tissues of cattle

Several experiments were conducted to determine the extent to which insecticides are stored in the fatty tissue of cattle. In one experiment two groups of four Hereford cows were sprayed five times at 28-day intervals with 0.5 percent of DDT, a wettable-powder spray being used on one group and an emulsion on the other. Each of the cows was suckling a calf, but only two of the calves in each group were sprayed. One month after the last spraying, all the animals were slaughtered and samples of the fat were analyzed for DDT content. The fat from the cows treated with the emulsion spray showed an average of 15.2 parts per million, and from those receiving the wettable-powder spray 14.6 parts per million. The fat from the treated calves averaged 52 parts per million, whereas that of untreated calves suckling on treated cows showed 25 parts per million.

An extensive experiment with toxaphene was undertaken in cooperation with the Hercules Powder Co. Hereford steers 6 to 9 months old were sprayed with 0.5-percent toxaphene emulsion, some at intervals of 2 weeks and others of 1 month. Six groups of 2 or 3 animals received from 1 to 10 treatments and 6 animals received 12 treatments. Fat samples were taken by biopsy from each group before and after treatment, and analyzed for organic chloride. The results showed little evidence of accumulation of toxaphene in the fat. The technique of taking fat samples at intervals from the experimental animals has greatly advanced progress in investigations on the toxicity of insecticides to livestock.

New Insecticides Tested Against Livestock Pests

Experiments with the new insecticides for the control of livestock pests were continued.

For the control of horn flies on cattle, methoxychlor, TDE, and toxaphene were about equally effective. Sprays containing 0.5 percent of any of these insecticides provided good control for 3 to 4 weeks. A spray containing 0.1 percent of pyrethrins plus 1 percent of piperonyl butoxide was effective for about 1 week. DDT is still recommended for the control of horn flies on beef animals. TDE and methoxychlor are also recommended for this purpose.

In tests against stable flies, methoxychlor was found to be superior to DDT when applied to screen cages as a residual treatment, especially when the cages were exposed to sunlight. When applied to animals both methoxychlor and pyrethrum-piperonyl butoxide either repelled the flies or killed most of those that fed during the first 3 days after the treatment.

Satisfactory control of the Gulf coast tick on cattle was obtained with toxaphene and also with a combination of DDT and benzene hexachloride when the animals were treated every 2 to 3 weeks. DDT alone was not effective against engorged ticks. Dips or sprays containing 0.5 percent of toxaphene or 0.5 percent of DDT plus sufficient benzene hexachloride to give 0.025 percent of gamma were used. Chlordane was also promising for the control of ticks affecting livestock. Methoxychlor was in general less effective than the other chlorinated hydrocarbons tested.

Against the sheep tick benzene hexachloride, chlordane, and toxaphene continued to be superior to other chlorinated hydrocarbons. Dips gave better control than sprays. A single dipping with certain concentrations gave complete control. However, sprays containing 0.5 percent of chlordane or technical benzene hexachloride (0.05 percent of gamma isomer) generally gave excellent practical control when applied in proper amounts with suitable equipment, especially on sheep recently shorn or with short fleece.

Tests in 1948 confirmed previous reports that none of the chlorinated hydrocarbon insecticides were effective for the control of cattle grub larvae in the backs of animals. Treatments with all the commercially available insecticides of this type at 2-week intervals during the egg-laying season failed to prevent cattle grub infestations.

Sprays made from finely ground derris were more effective than those from emulsifiable rotenone extracts.

FOREST INSECTS

Outbreaks of Pine Bark Beetles in Western Forests Being Controlled

The large-scale spray programs for the control of pine bark beetles in Idaho, Wyoming, and South Dakota conducted in the spring of 1948 were very effective, according to surveys made in the fall. However, there was a sharp increase in infestations on certain untreated areas. Control operations were again undertaken in the spring of 1949.

On the Black Hills and Harney National Forests in South Dakota the fall survey showed 16,000 ponderosa pine trees outside the treated area to be infested with Black Hills beetles. In Wyoming, where about 110,000 lodgepole pines in the Targhee-Teton area were treated in 1948, the infestation of mountain pine beetles was reduced by about 75 percent. By treating these trees in 1949 it is hoped that the outbreaks will be cleaned up, or at least checked to the point where only a small amount of maintenance work will be needed annually. These control programs are being conducted by the Forest Service, the National Park Service, and State agencies, under the technical supervision of this Bureau.

Surveys in Colorado in the fall of 1948 showed an extensive outbreak of the Black Hills beetle involving 23,000 ponderosa pine trees in the Roosevelt National Forest and a smaller outbreak in 4,500 trees in the Denver Mountain Parks area.

Lodgepole pine stands in the Thompson River drainage of Montana were found to be seriously infested with the mountain pine beetle early in 1949. About 20,000 trees in an area of 35,000 acres were involved. Control operations were begun in June, private landowners paying their share of the costs.

Another large outbreak of the mountain pine beetle in lodgepole pine on the Ashley and Wasatch National Forests in Utah was found to have increased from about 37,500 infested trees in 1937 to more than 112,000 in 1948. Since timber values are relatively low in these forests, control is considered impractical.

Bark Beetles Controlled Through Sanitation-Salvage Cuttings

Ten years' testing of sanitation-salvage cuttings on the Black Mountain Experimental Forest have given results in bark beetle control that have far exceeded expectations. These cuttings remove from the forest all trees that are of poor health, and thus deprive the beetles of trees in which to breed up populations of epidemic proportions. Through the cutting of 16 percent of the merchantable green-stand volume in trees of immediate risk to beetle attack, pine mortality has been reduced by 71 percent on 148 acres treated 10 years ago and by more than 87 percent on other areas treated from 6 to 9 years ago. This reduction represents a saving in pine volume of about 476 board-feet per acre over the period of the cutting.

The highly successful results of this program have prompted Federal and private land-managing agencies to adopt this method of bark beetle control in treating several hundred thousand acres of ponderosa pine timberlands in northeastern California and eastern Oregon. Its use has brought tremendous savings to landowners as compared with those obtained by previous methods, which destroyed beetle populations only after damage and loss to timber had occurred.

Interest in preventing losses caused by bark beetles in stands of ponderosa pine has also been stimulated among lumber companies in the northern Rocky Mountains. One large company practices a light selection cutting in all its lumbering operations. From 30 to 50 percent of the stand volume is removed, chiefly in trees most likely to be killed by beetles within the next 20 years. Other large companies are planning to do likewise. Two permanent demonstration areas have been established in western Montana on public and private lands, where each tree has been marked to indicate its susceptibility to attack by bark beetles. These areas are being used to demonstrate marking principles as an aid to company foresters in adapting the practice to their needs.

Mountain Home Owners of Southern California Combat Bark Beetles

In 1947 *Ips* and *Dendroctonus* beetles invaded areas in the mountains of southern California where millions of dollars have been invested in resorts and summer-home developments. Hundreds of property owners promptly organized to combat the epidemic. During the winter and spring of 1947–48 private, county, State, and Federal agencies pooled their resources to carry out an eradication campaign under Bureau supervision in the area around the town of Julian in San Diego County. About 2,250 infested pine trees were treated, mostly by felling and burning. This first effort brought about a reduction of 60 to 75 percent in the number of trees killed during the 1948 season. Work was next concentrated on the surviving infestation, which overwintered in trees attacked in the fall of 1948. Both burning and toxic oil treatments were used. All indications in the spring of 1949 were that this outbreak had been brought to an end. The project has also demonstrated the value of cooperative community effort in dealing with bark beetle problems in areas where many small ownerships are involved.

Ips Infestations Affected by Climate

The frequent flare-up of *Ips* infestations in and around timber cuttings by small mills since 1945 has emphasized the need for better understanding of the ecological factors governing the abundance of these bark beetles. Recent studies throughout the pine types of California have brought to light much new information on this problem.

During the 1948 season there was a general subsidence of outbreaks in many areas, whereas the reverse was true in the season of 1947. The climate during these 2 years showed striking differences. In 1947, when *Ips* populations were increasing, precipitation was well below normal, soil mosture was below normal during most of the growing

season, and air temperatures were above normal early in the season. In contrast, the 1948 season, when *Ips* beetles were subsiding, was characterized by precipitation above normal during the spring months, soil moisture above normal, and temperatures well below normal for the entire season. The low temperatures in 1948 retarded *Ips* development so that only two and one-half generations were produced as compared with three and one-half generations in 1947.

The importance of precipitation and soil moisture was further shown by a review of recorded *Ips* outbreaks during the last 25 years. Most of these epidemics occurred in years when the precipitation showed a cumulative monthly deficiency from January to June.

The information that has been acquired through these investigations is of value in applying preventive measures, such as timing of cuttings and treatment of slash, to avoid serious losses from *Ips* infestations in reserve stands.

Aerial Spraying Controls Spruce Budworms

The outbreak of the spruce budworm that has been building up in Oregon and Washington continued to develop in 1948. About 1,000,000 acres were known to be infested in 1947, chiefly in the Blue Mountains in the northeastern part of Oregon. In 1948 new centers of infestation were found east of Mount Hood and near Eugene, bringing the total to nearly 1,500,000 acres.

The infestations in the central and southern Rocky Mountain regions declined, except in northern New Mexico. Several areas of severe defoliation were reported in the northern Rocky Mountain region, but it has not been possible to determine how extensive they are.

For the second year the budworm populations in northern New York declined noticeably. Birds played a conspicuous part in destroying the larvae. There was little change in Vermont and New Hampshire, but a marked increase in Maine. In the northern part of Aroostook County half the new balsam fir foliage in some stands was eaten in 1948, which indicated the danger of outbreak proportions in 1949.

An encouraging development was the highly successful control of the budworm in an aerial spraying experiment conducted in Oregon with the cooperation of the Oregon State Board of Forestry and the United States Forest Service. Test plots totaling 4,200 acres were sprayed during the last 10 days of the larval feeding period in July 1948. The spray was applied with an airplane and a helicopter at the rate of 1 pound of DDT in 1 gallon of fuel oil per acre and gave between 95 and 100 percent control. On the basis of these results, these agencies and timberland owners are cooperating with this Bureau in a control program aimed at spraying about 200,000 acres of the most valuable Douglas-fir and true-fir stands in 1949.

Resistant Strains of Pines May Solve Weevil Problem in California

Planting to restock areas that were originally forested but were taken over by a heavy cover of brush after logging and fires has encountered some striking failures. In northern California, where

planting with the valuable ponderosa and Jeffrey pines was attempted, many of the trees died during the first decade owing to inroads by a pine reproduction weevil (*Cylindrocopturus eatoni* Buch.).

Recently new strains of pine developed by the Institute of Forest Genetics at Placerville, Calif., have been tested under cage control by forest entomologists to determine their resistance to weevil attack. The most resistant strain yet found is a cross between Jeffrey and Coulter pines. The Jeffrey parent of this new hybrid has excellent wood qualities but is susceptible to the weevil; the Coulter parent is highly resistant to the weevil but has inferior wood qualities. Thus far the hybrid has shown resistance to weevil attack equal to that of Coulter pine. In 1948 field plantings were made to test this new hybrid in brush-field areas where Jeffrey and ponderosa pine had failed. If the hybrid shows the same degree of resistance in these field plots as it has in preliminary tests, the prospects for successfully planting brush-field areas with a fast-growing, good-quality variety of pine will be greatly improved.

Engelmann Spruce Beetle Still Active in Colorado

The outbreak of the Englemann spruce beetle in Colorado appeared to be dying out in 1947, after killing about 4 billion board-feet of spruce, valued at about $8,000,000. This loss represented about one-tenth of the timber volume in Colorado. Surveys in the fall of 1948 showed that the infestation was still spreading in a northeasterly direction into the Routt and Arapaho National Forests and threatening extensive spruce stands farther east. In its wake practically all the spruce trees eight or more inches in diameter had been killed. At first only the larger and overmature trees were killed, but since 1946 the beetles have attacked even the young and most vigorous trees left in the area. The loss of the young stand in addition to the mature trees will greatly reduce the possible harvest for many years to come. Fortunately, there is enough natural spruce reproduction to regenerate the forest on the hundreds of thousands of acres involved in the outbreak, provided the area can be protected from fire. Every effort is being made to salvage the dead trees for pulp.

Research on Insects Affecting Forest Products Shows Progress

Studies on the biology and control of insects affecting forest products have been continued in cooperation with the Army Corps of Engineers.

It has been found that large populations of *Lyctus* powder-post beetles can be reared for testing purposes on freshly cut and seasoned limb wood of oak, ash, and hickory. Beetles fed on this favorable material mature in 4 months instead of the normal 9 months. In experiments for the control of these beetles, DDT, benzene hexachloride, chlordane, toxaphene, and pentachlorophenol, applied as 3-minute dips, were found to be effective as both preventive and remedial measures under laboratory conditions. Tests with fumigants were continued at the Army storage depot at Mira Loma, Calif. About 62,000 infested wooden cots were fumigated under tarpaulins for 72

hours with methyl bromide at the rate of 3 to 4 pounds per 1,000 cubic feet, and complete kill of these beetles was obtained.

Earlier indications that toxic sprays would give practical control of ambrosia beetles in green logs and lumber were substantiated in applications made under operating conditions in the woods and in the lumberyard. Hydraulic sprayers and fogging machines were used. Benzene hexachloride at 0.4–0.8 percent of the gamma isomer in fuel oil had given nearly complete protection to fresh-cut logs for 2 to 4 months in tests still under way at the end of the year. Lumber was protected with a gamma-isomer concentration of only 0.1–0.2 percent.

New Program of Forest-Pest Surveys Organized

Much time and effort have been devoted to organizing and planning a broad program of annual forest-pest surveys as authorized by the Forest Pest Control Act of 1947. The purpose of these surveys is to detect outbreaks before they become widespread and cause serious damage. It should then be possible to apply control measures at a reasonable cost and prevent the tremendous losses that have been far too common in past years. Funds for implementing this program have been provided for the fiscal year 1950.

Gypsy Moths

Cooperative programs expedite control

The gypsy moth, a serious pest of forest and shade trees in the northeastern part of the country for the last 60 years, can now be controlled with a single application of DDT. Such control has been made possible by developing new methods of treatment utilizing new types of equipment and accomplished through organized cooperative programs. In addition to spray operations these programs include extensive surveys to determine the need for and the results of spraying. Not only have Federal and State agencies taken part in this program, but local communities, private agencies, and individuals have also participated.

Airplanes are used to spray DDT over large forest areas, and mist blowers operated from the ground for treating trees in residential areas and along highways. Oil solutions of DDT are applied at the rate of 1 gallon per acre. One application of a 12-percent solution when the eggs are hatching is usually effective for an entire season. For any later spraying a 6-percent solution is used. The cost of all aerial spraying in 1949 was less than $1 per acre, and of spraying with mist blowers about 60 cents per acre.

The last untreated portion of the infested Scranton-Wilkes-Barre area in Pennsylvania, comprising about 135,000 acres, was sprayed by aircraft in 1948, and no more moths had been found there up to the end of June 1949. In the spring of 1949 most of the spraying in this area was done with mist blowers and knapsack pumps. However, more than 30,000 acres in the Quakertown section, about 60 miles southeast of Wilkes-Barre, where an isolated infestation was discovered by survey in the fall of 1948, were sprayed by aircraft.

860448—49——3

Nearly 425,000 acres were sprayed in New England, New York, and Pennsylvania in the spring of 1948, all but about 33,000 acres by aircraft. More than half of this acreage was on Cape Cod. This is the largest spray program ever attempted in the gypsy moth infested area. The Bureau used one of its C–47 and several N3N–3 airplanes. In New York two State-owned Stearman biplanes were used, and on Cape Cod, in addition to Bureau and Air Force aircraft, several types of commercial planes and helicopters were operated on contract. For ground spraying 10 mist blowers were operated, 7 of which are federally owned.

More than 6,000,000 acres in the infested States and contiguous areas of Canada were surveyed with the aid of sex-attractant traps, and another 2,000,000 acres were surveyed by trained inspectors in the summer of 1948. No male gypsy moths were caught in the areas surveyed with traps in Pennsylvania, New Jersey, and Canada. The records of captures in New York and New England were used in preparing plans for subsequent scouting and spraying. The results of the surveys indicate that the westward limits of the infested area have been determined.

Cape Cod initiates its own spray program

The control program conducted on Cape Cod, Mass., in the spring of 1949 was a significant innovation in that it was initiated by the local community. Barnstable County, which is Cape Cod, and the State conservation department made funds available for spraying the entire county. Several towns also gave financial assistance. This Bureau, in addition to furnishing an airplane and pilot, assigned technically trained personnel to help coordinate the program and to check results. About 230,000 acres, practically the entire Cape, were sprayed, all but 1,400 acres by airplane. Included were about 22,600 acres of Army property, including Camp Edwards and a small area at Wellfleet, which was sprayed by the Air Force. Other airplanes and also helicopters were used by a commercial spraying company under contract.

Frequent observations during the spray operation, in May and June 1949, showed tremendous mortality of gypsy moth larvae. The entire Cape will be trapped during the summer to determine the effectiveness of the spraying.

The effect of the spraying on other forest insects, and on tick populations was determined by Bureau workers, and State specialists on fish biology, wildlife, public health, and reclamation, as well as the Massachusetts Audubon Society, joined in the program.

Collection of attractant for survey traps increased

The cost of obtaining attractant from female gypsy moths for use in survey traps was greatly reduced, from 6.4 cents per trap in 1946 to 2.2 cents in 1948, in spite of increased labor costs. This reduction was made possible by an excellent collecting season and improvements in technique of collection and method of handling the pupae. An improved type of trap was also used.

More than 1.8 million female gypsy moth pupae were collected in the summer of 1948, and from this record number the terminal segments

of more than 1 million moths were obtained. Because of these records it was possible (1) to double the allotment (to 200,000 charges) of attractant material for research purposes, (2) to allot 17,000 charges for surveying more than 7 million acres during the summer of 1949, (3) to stock-pile attractant for future use, and (4) to discontinue collections of pupae for 1 year since a new chemical treatment keeps the material potent for several years.

An innovation of the season was the testing in New England of such attractant from gypsy moths obtained by the Bureau from North Africa. This material proved satisfactory, and assures the availability of attractant should the rapidly increasing use of DDT in New England prevent large collections of pupae in the near future.

Active constituent of gypsy moth attractant studied

Progress has been made in the investigation of the chemical nature of gyptol, the active constituent of the gypsy moth attractant. By preparing a *p*-phenylazobenzoyl ester from the neutral portion of the benzene extractive of the female terminal segments and subjecting it to chromatographic separation on a magnesium carbonate column, a fraction can be obtained which contains all the gyptol. Testing of the attractiveness of the various fractions has been greatly expedited by the development of a laboratory technique for rearing male gypsy moths eggs collected in the fall and kept in cold storage. Products obtained in chemical studies can now be tested during the winter, whereas it formerly was necessary to hold all materials for field tests during the following summer.

Preventing spread of gypsy moths through regulatory activities

Substitution of annual nursery-wide DDT spraying for individual plant inspection or treatment was approved on April 15, 1949, as a basis for certification of plants under gypsy moth-quarantine regulations. All nursery plantings for which certification is desired are sprayed. Nursery surroundings are also included when necessary to prevent reinfestation of the premises. The spray is applied at the rate of 2 pounds of DDT per acre. Mist blowers delivering 2 gallons of DDT concentrate per acre or hydraulic sprayers applying the same amount of DDT in 600 gallons of solution have been used successfully in these operations. Spraying between the time of the spring egg hatch and pupation of the caterpillars qualifies the nursery stock for certification from the following July 1 until the next year's egg hatch, when spraying must be repeated. In June 1949 four large establishments sprayed in this manner 200 acres of nursery areas.

Adjustments have been made in a number of fumigation methods and procedures. Revised instructions, issued September 28, 1948, prescribe a slight increase in methyl bromide dosage for fumigation of Christmas trees, evergreen boughs, lumber, cordwood, quarry products, scrap iron, sawdust, shavings, wood chips, excelsior, and excelsior waste. Fumigation of such articles in boxcars is now restricted to cars of all-steel construction. Tighter sealing of all cracks through which the gas might escape is also required. Provision for the introduction of methyl bromide gas through a ½-inch T-nozzle propped against the

ceiling to direct the gas toward each end of the car has eliminated the need for fans to circulate the fumigant.

Among the large-scale inspection accomplishments in 1949 were the certification of 178,000,000 board-feet of lumber, 229,000 logs and poles, 125,000 cords of pulpwood and fuel wood, 132,000 bales of excelsior, and 993,000 units of other forest products. In addition, 26,420,000 plants, 418,000 Christmas trees, 568,000 tons and 424,000 pieces of granite, marble, and stone were inspected or treated prior to being certified for movement from the area infested by gypsy moth. Certification of this material required 24,450 calls by 24 district inspectors. Estimated valuation of certified products is $64,600,000.

Incidental to the routine examination for gypsy moths, inspectors scouted for *Phyllobius intrusus* Kono, an introduced weevil known to attack arborvitae in several New England nurseries, and for any possibly escaped infestations of the European chafer, now established in southern Wayne County, N. Y.

TRUCK-CROP AND GARDEN INSECTS

Organic Phosphorus Compounds Outstanding Against Greenhouse Pests

Aerosols containing commercial tetraethyl pyrophosphate or hexaethyl tetraphosphate with methyl chloride as the propellent gas have continued to give spectacular control of aphids, thrips, whiteflies, and red spider mites in greenhouses. Commercial growers have been using these aerosols during the past year with striking increases in production, particularly during the summer months. In one house alone the production of roses during the month of August increased from 28,000 to 129,000 blossoms. Increase in stem length of roses was also notable.

Reducing the particle size of hexaethyl tetraphosphate aerosols to less than 20 microns in diameter made them more effective, even though this reduction was accomplished by decreasing the strength of the aerosol from 10 percent to 1 percent. It was found that only the particles less than 20 microns in diameter remain in the air more than 4 minutes and that the larger particles appear to be chiefly responsible for plant injury and have little effect on the insects.

Parathion aerosols have been found especially effective against certain leaf tiers, mealybugs, and roaches that are difficult to control. They are now supplementing aerosols containing hexaethyl tetraphosphate for this purpose. Until more is known about the stability of parathion residues, these aerosols should not be used on vegetable crops after the edible parts have formed.

Several new phosphorus compounds related chemically to parathion and tetraethyl pyrophosphate are also highly toxic to various greenhouse pests. In comparative tests octamethyl pyrophosphoramide was found to be the most effective against a resistant strain of the two-spotted spider mite, followed in order by tetraethyl bithiopyrophosphate, tetraethyl pyrophosphate, and parathion. Diethyl *p*-nitrophenyl phosphate and tetraethyl monothiopyrophosphate have also been found highly toxic to mites and aphids. Octamethyl pyrophosphoramide was found to act as a systemic poison; that is, when applied

to the soil it was taken up by the plants and killed aphids and mites feeding on them.

Parathion Effective Against Green Peach Aphid on Tobacco

The green peach aphid continues to cause grave concern to tobacco growers. Light but widespread infestations were reported from North and South Carolina, Georgia, and Florida in April 1949. In North Carolina they remained light to moderate, but in the other three States by the last of June the pests had built up to the highest populations since 1946, when they first appeared on tobacco. Infestations were reported from Maryland, Virginia, and Tennessee in May, and from Connecticut in June.

In experiments during the past year progress was made toward finding a suitable method of control on shade-grown tobacco in Florida. Encouraging results were obtained with dusts containing 1 percent of parathion. No injury to the plants was evident. A dust containing 1 percent of the essentially pure gamma benzene hexachloride was fairly effective against light infestations, although less so than parathion, but technical benzene hexachloride was found to injure the tobacco plants. Promising results were also obtained with sprays containing 1 pint of 10-percent tetraethyl pyrophosphate in 100 gallons of water. The addition of a 10-percent DDT dust to the parathion provided protection against associated infestations of hornworms, budworms, and garden fleahoppers in one treatment.

In Florida the destruction of the favorite host plants, such as collards and several species of weeds, in and around fields where shade tobacco was grown aided materially in controlling the aphids.

Effect of Insecticides on the Yield and Quality of Tobacco Tested

The effect of mixing DDT, benzene hexachloride, and toxaphene in the soil on the yield and quality of tobacco grown therein was studied at Florence, S. C., in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the South Carolina Agricultural Experiment Station. DDT in dosages up to 40 pounds per acre had no adverse effect on the tobacco; an excessive dosage of 100 pounds per acre tended to impart a slightly abnormal sweet taste to the cured product but did not affect the yield. Technical benzene hexachloride in dosages as low as 2 pounds of the gamma isomer per acre gave an off-taste, and excessive dosages ranging from 6 to 10 pounds of gamma per acre reduced the yield slightly as well as the quality. Toxaphene at 20 pounds per acre slightly retarded the growth of tobacco plants and reduced the yield.

The effect of foliage applications of various insecticides on the taste and aroma of the tobacco was studied in cooperation with the tobacco industry. The tests were made by tobacco experts, or specialists in judging various aspects of tobacco quality. The insecticides used were DDT, benzene hexachloride, toxaphene, parathion, and tetraethyl pyrophosphate. Technical benzene hexachloride was the only material that showed any consistent evidence of deleterious effect on the

aroma or taste of tobacco. These studies should be continued on tobacco grown in different environments.

The results of both investigations indicate that, with the exception of the off-taste caused by all dosages of benzene hexachloride, these insecticides will not injure the tobacco when used under practical field conditions. Whether they will ever accumulate in injurious quantities in the soil as the result of normal insecticide applications to tobacco foliage is unknown at present.

New Fumigant for Cigarette Beetle in Stored Tobacco

A new fumigant containing equal parts of acrylonitrile and carbon tetrachloride has given better control of the cigarette beetle in closed tobacco storages under commercial fumigation conditions than the hydrogen cyanide now commonly employed by the industry. At dosages of 2 to 2½ pounds per 1,000 cubic feet, this new material killed cigarette beetles to a greater depth in the tobacco containers than did the hydrogen cyanide. It was successfully used in cigarette, Turkish, and various types of cigar tobaccos without injurious effects.

Control of Aphids on Potatoes Improved

Experiments were conducted in Maine to determine the most economical form of DDT insecticides for the control of aphids on potatoes. Dusts and suspensions protected the crops longer than emulsions, and dusts impregnated with oil were more effective than dusts in which the oil had been mixed with the DDT by mechanical means. Reduction in the spread of leafroll disease following DDT spray treatments for the control of aphids was demonstrated for the first time. Toxaphene spray injured the foliage of Katahdin potatoes and did not give satisfactory control of aphids.

In the Yakima Valley of Washington tetraethyl pyrophosphate was shown to be effective against aphids on potatoes when it was applied as a dust by airplane. This was found to be one of the best methods of killing these aphids after the plants had become large enough to meet between the rows.

DDT Gives Best Residual Action on Pea Aphid

In experiments in Wisconsin, Washington, and Oregon, DDT dusts gave as good immediate control of the pea aphid as those containing parathion, rotenone, or tetraethyl pyrophosphate, and in residual action were far superior to the other materials. The residual action of parathion did not extend beyond approximately 10 days. Because of the residue on pea vines, however, DDT should not be used when the vines are to be fed to milk cows or animals being finished for slaughter.

New Insecticides Effective Against Aphids on Cole Crops

The turnip aphid was controlled with parathion dust at strengths as low as 0.25 percent and the cabbage aphid at 0.5 to 1 percent, in

experiments in the South and in California. Tetraethyl pyrophosphate was also effective against the cabbage aphid, and dusts were better than sprays. Dusts containing this insecticide were found to be superior to the formerly recommended nicotine, and since they are also cheaper they are now being widely used by growers. A 1-percent gamma benzene hexachloride dust prepared from the essentially pure gamma isomer was superior to a dust of the same gamma-isomer content prepared from technical benzene hexachloride against associated infestations of the turnip aphid and cabbage caterpillars.

Cost of Controlling Cabbage Caterpillars Reduced

DDT dusts have continued to give good control of the several species of caterpillars occurring on cabbage before the heads begin to form. In commercial practice this material has almost completely replaced the rotenone, arsenic, and fluorine insecticides formerly used, at a lower cost. A dust containing 1 percent of DDT plus 2 percent of a methylated naphthalene was found to be as effective as a 3-percent DDT dust, and also cheaper.

Insecticides Kill Melonworms and Pickleworms on Cucumbers

Gamma benzene hexachloride and parathion dusts containing 1 percent of the active ingredient gave satisfactory control of the melonworm and the pickleworm on cucumbers without causing appreciable injury to the plants. Technical benzene hexachloride, chlordane, and DDT injured cucumber plants in tests near Charleston, S. C. For use during the picking season dusts containing 20 percent of sabadilla, 40 percent of ryania, or 0.3 percent of pyrethrins were more effective than 1-percent rotenone dust against the pickleworm.

Remedy Sought for Serpentine Leaf Miner

Outbreaks of the serpentine leaf miner on tomatoes, melons, and certain other truck crops in the Southwest and also in Florida have made it necessary to search for a means of controlling this insect. In California toxaphene and chlordane were effective either in dusts or in concentrated sprays. These insecticides also controlled the tomato fruitworm. In Arizona sweetened sprays containing chlordane or toxaphene were very toxic to adults of this leaf miner, but they also greatly reduced the number of its parasites. Some evidence has been obtained that these baited sprays also kill the leaf miner larvae within the leaves.

Soil Insecticides for Wireworms Evaluated

Recommendations on the use of ethylene dibromide as a soil fumigant for the control of wireworms in irrigated lands were issued during the year.

Tests with soil insecticides showed that DDT, chlordane, and toxaphene will materially reduce wireworm populations. DDT acted more slowly than the other materials, but experiments thus far indi-

cate that a single application will keep wireworms in irrigated lands at a low level for 4 or 5 years. Experiments to determine the effect of accumulations in the soil on crop production are still incomplete, but indications are that neither chlordane nor toxaphene will be dissipated more quickly than DDT.

Onion Thrips Controlled With Several New Insecticides

That DDT, chlordane, and toxaphene will control the onion thrips on bulb onions or onions grown for seed, if applied at fairly high dosages, has been shown by extensive field-plot experiments in California and Idaho. Ten-percent dusts were more effective than 5-percent, and emulsions were better than wettable-powder sprays of the same strength. All these insecticides appeared to be about equal in effectiveness, although there were some indications that chlordane may be slightly better than the other two. On bulb onions three applications are required at 2-week intervals beginning when the plants are 10 inches high.

Parathion gave promising results when applied as 1- or 2-percent dusts, but it had less residual action than the other materials. If residues do not persist, it may be particularly useful in combating thrips on spring onions, which are harvested comparatively soon after the treatment.

New Insecticides Kill Insects Affecting Sugar-Beet Seed

During the past year 5-percent DDT dust has been adopted as a standard insecticide for the control of plant bugs on sugar beets grown for seed. In further experiments on insects affecting sugar-beet seed, dusts containing 2 percent of gamma benzene hexachloride or parathion were found to be effective against the Say stink bug, and a DDT emulsion was found to reduce the percentage of plants affected by curly top disease carried by the beet leafhopper. However, according to information thus far available, the DDT emulsions must be applied so frequently that the cost of the treatment is too high to be of practical value.

Sweetpotatoes Protected from Weevil Damage

Suppression of the destructive sweetpotato weevil is vital to the success of the important and expanding sweetpotato industry in the Southern States. Over a period of years quarantine, survey, and control measures have been applied cooperatively by Federal and State agencies in commercial production areas in Alabama, Georgia, Louisiana, Mississippi, South Carolina, Texas, and northwestern Florida. Since 1937 a total of 37 counties, including 8,909 farms and storage places, have thus been cleared of weevils. In the calendar year 1948 weevils were eradicated from 916 infested farms, and planting restrictions on them were withdrawn.

Outside of Louisiana and a limited area in Texas only a very small proportion of farms in the commercial sweetpotato districts are now

known to have weevils. At the end of May 1949 there were only 500 known infested properties in these five States. In Louisiana there are still numerous infestations, largely in those districts into which the suppression program has recently expanded. A highly developed realization of weevil damage among farm, industrial, and business circles now promises to result in effective reduction of the pest in this key State.

NEMATODES INFESTING POTATOES

Golden Nematode Not Found Outside of Long Island

Extensive surveys conducted in the principal potato-production areas of 22 eastern, midwestern, and southern States with the cooperation of State pest-control officials failed to reveal the presence of the golden nematode outside the known center of infestation on Long Island, N. Y. Soil samples collected outside of Long Island in potato fields and at graders or other sites where Irish potatoes are concentrated numbered 29,224, representative of 232,910 acres. On Long Island intensive field surveys which involved the collection of 51,674 soil samples from 37,545 acres resulted in the finding of infestations on 1,681 additional acres. At the end of June 1949 infestations were known to occur on 8,168 acres. Of this total, 7,557 acres are located in Nassau County within and near the village of Hicksville. The remaining 611 acres comprise 14 scattered properties in westerly Suffolk County.

Over 3,300 acres of known infested lands were withheld from potato and tomato production during the crop year under the Federal-State compensation program. Federal funds for compensating owners who also complied with specified sanitation conditions were authorized in the Golden Nematode Act passed by the Eightieth Congress. Federal payments were limited to farmer owned and operated lands comprising 2,418 acres. An equal share of compensation was paid by the State of New York, which also assumed responsibility for compensation on 921 acres of rented lands.

By June 30, 1949, over 2,500 acres of known infested lands in Nassau County had been removed from cultivation and diverted into real-estate and industrial developments. Such action resulted in the movement of over 300,000 cubic yards of infested topsoil, valued at an estimated $1,000,000. The Bureau assisted New York State in supervising this movement, as well as in enforcing the State's quarantine regulations on the movement of culinary potatoes, root crops, and farm machinery.

The Bureau cooperated with the Bureau of Plant Industry, Soils, and Agricultural Engineering, and with the New York State College of Agriculture and Department of Agriculture and Markets in the development of approved methods for treating potato tubers, used containers, or topsoil and in the conduct of experiments relating to effective control chemicals and methods of application. In order to conform with quarantine requirements and prescribed methods of

860448—49——4

washing or treating potato tubers grown on regulated lands, local growers financed and erected a $200,000 processing plant.

The potato rot nematode survey in the Northwestern States gave ready access to numerous potato lots in cellars, storages, and grading operations, and made it possible to collect soil samples in these locations and from refuse piles and waste dumps. Such soil samples incidentally obtained direct from intimate association with the potato host were ideal places in which to detect golden nematode cysts in case this parasite were present in that region. Accordingly, 378 samples of such soil collected from 142 locations were forwarded to the Bureau's Hickville, Long Island, laboratory for the standard washing and screening procedure. No trace of golden nematode was found in any of them.

Potato Rot Nematode Limited to Small Area in Idaho

The potato rot nematode, long present in northern Europe as a rot-producing parasite on potato tubers, is known on the American continent from only two localities—a small area near Aberdeen, Idaho, and on a few potato farms in the Province of Prince Edward Island, Canada. The Idaho infestation was recognized in 1943, and this nematode was reported from Prince Edward Island in 1945. Surveys by Canadian authorities in 1946 revealed no widespread infestation on Prince Edward Island, nor was it found in the 14 northeastern States scouted by Bureau and State officials. Neither in these surveys nor in additional search made in 1947–48 incidental to golden nematode surveys in New York and New England was any rot nematode disclosed.

In December 1948 rot nematode infestation was reported in a second county in Idaho. A survey was then undertaken cooperatively with the States of California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, and Washington to determine whether the nematode was present elsewhere in the Northwestern States. It was carried out during the period of the spring potato movement from storage to market, largely in March and April 1949. At this season the tuber rot symptoms produced by the internally developing nematodes are most evident and large volumes of potatoes can be examined during the grading process. In these operations 221,643 bushels of potatoes, representing the crops of 1,024 growers in 66 counties, were examined. Of this total, 128,914 bushels coming from 702 farms were seen in 11 Idaho counties. Samples of all suspected tubers found were referred for technical determination to nematode experts in Idaho or in the Bureau of Plant Industry, Soils, and Agricultural Engineering, but no case of rot nematode was encountered outside the known infested area in Idaho. This fortunate outcome, especially when considered in conjunction with the negative results from the previous surveys, seems to indicate that the potato rot nematode is not widely prevalent in our important potato-producing areas, outside of the small section in Idaho, where incidence is in general light and limited to less than 20 farms.

FRUIT AND NUT INSECTS

Phony Peach Vectors Incriminated

Climaxing 12 years' experimentation, definite evidence was obtained in 1948 that certain leafhoppers transmit the phony peach disease. This virus disease has caused the loss of more than one million peach trees since 1929. Inspection of peach trees exposed to infection in insect-transmission tests begun in 1945 and 1946 resulted in the finding of 14 definite and 10 probable cases of phony peach. Four species of leafhoppers—*Homalodisca triquetra* (F.), *Graphocephala versuta* (Say), *Oncometopia undata* (F.), and *Cuerna costalis* (F.)—were definitely incriminated as capable of transmitting phony peach. All four of these leafhoppers are general feeders, and the first three are known to be associated with peach trees at certain seasons. *C. costalis*, although not commonly found on peach trees, has survived for a month or more when confined on peach. It is possible that other species, particularly members of the Tettigellinae, the group to which all the incriminated leafhoppers belong, may also spread the disease. Several other species of this group are of common occurrence in the area in which phony disease spreads rapidly. This work has been done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Discovery of insect vectors of phony peach disease opens up a new avenue of approach in the development of methods of restricting or preventing its spread. A large-scale experiment aimed at control of the vectors has already been undertaken in Georgia, where DDT has been applied to more than 90,000 peach trees. Because of the long incubation period of the virus causing the phony disease, at least two growing seasons, the results will not be measurable until 1951. This large-scale experiment supplements a number of large block tests with DDT that were started in 1947, when the identity of the vectors was already suspected.

Tests of New Insecticides Against Fruit and Nut Insects Continued

The practical development of promising new insecticides and the preliminary evaluation of other newly available materials constituted a major portion of the work on pests of fruits and nuts. The more important results of this work are reported in the following paragraphs, except those with parathion for scale-insect control, which are presented in a separate section. These results should not be considered as recommendations for the general use of these materials.

Apple insects

In codling moth control DDT continued to give outstanding results and was superior to all other materials tested. From 1 to 2 pounds of a 50-percent wettable powder in 100 gallons was used in three to six cover sprays, depending on the region. In Indiana a 25-percent parathion wettable powder was about as effective, pound for pound, as 50-percent DDT when the spray interval did not exceed 1 month. Five applications of a spray containing 10 ounces of such a powder in 100

gallons gave commercial control in New York, but 5 ounces in 100 gallons, the amount effective against certain mites, did not control the codling moth in the Pacific Northwest. In West Virginia TDE and ryania showed promise against light codling moth infestations, but in Indiana TDE was less effective than DDT. In New York DDT was more effective against the codling moth when applied with the conventional hydraulic sprayer than when applied as a concentrated spray with a mist blower.

Outstanding control of orchard mites was obtained with parathion when used at 4 ounces or more of 25-percent wettable powder per 100 gallons in all regular spray applications or at 8 ounces in two or more applications in Indiana, at 5 ounces per 100 gallons in two or three applications in the Pacific Northwest, and at 16 ounces in one or two applications in West Virginia. Other materials showing some promise in mite control included toxaphene, 1,1–bis(*p*–chlorophenyl)ethanol (DMC), 2,3,4,5,6–pentachloroanisole, and a mixed alkyl sulfite. The dinitrocaprylphenyl ester of crotonic acid, 2-laurylmercapto-2-thiazoline, and bis(*p*-chlorophenoxy)methane also showed promise, but in some instances caused injury to the fruit or foliage.

The red-banded leaf roller was controlled effectively in Indiana and West Virginia with TDE at 1 quart of a 25-percent liquid concentrate or 2 pounds of a 50-percent wettable powder in 100 gallons of spray, and with parathion at 1 pound of a 25-percent wettable powder. In West Virginia liquid TDE was outstanding, apparently because of its ability to penetrate the webs and reach the larvae. In Indiana 1 pound of 25-percent parathion per 100 gallons gave far more rapid and greater reductions in numbers of larvae than 4 pounds of lead arsenate or 1 quart of 25-percent TDE during the week after application, but at the end of 4 weeks these materials were equally effective. Parathion at less than 2 pounds of the 25-percent material per 100 gallons began to lose effectiveness 3 to 4 weeks after the last spray. Toxaphene in a full-season schedule also kept the leaf roller under control in West Virginia.

Against the woolly apple aphid in Washington, toxaphene at 1 pint of 50-percent water-miscible liquid concentrate per 100 gallons was extremely effective when used in two applications, as was also parathion at either 2½ or 5 ounces of 25-percent wettable powder per 100 gallons. Two early-season applications of 1 pound of technical benzene hexachloride (12 percent gamma) per 100 gallons also gave good control of this aphid, but the control did not hold up to the end of the season.

Parathion caused serious injury in McIntosh and related apple varieties in New York, especially early in the season, and severely russeted the fruit of the Jonathan and Golden Delicious varieties when used with or following the fungicide ferric dimethyl dithiocarbamate in Indiana.

Pear psylla

In both the States of New York and Washington summer applications of parathion, toxaphene, and rotenone (cube root) plus oil were again superior to nicotine sulfate and other materials for pear psylla

control, largely because of their greater residual effectiveness. After a hot, dry period in New York, a leaf scorch developed on Bosc and to a lesser extent on Bartlett pear trees sprayed with parathion.

Insect pests of stone fruits

In orchard tests against the plum curculio in Georgia, parathion and benzene hexachloride were superior to toxaphene or lead arsenate in preventing premature dropping of fruit and in holding the infestation in drops to a low level. Benzene hexachloride, parathion, and toxaphene, as used in regular schedules, caused no injury to peaches and did not affect the flavor of the fresh fruit. Both hexaethyl tetraphosphate and technical tetraethyl pyrophosphate, 1–800, injured peach foliage in Georgia, and the latter also injured fruit. Residue analyses indicate that about half the parathion deposited on peaches by spraying in Georgia is lost within 11 days after application and nearly all is lost within 4 weeks after spraying is discontinued.

In Indiana an infestation of the peach-tree borer was reduced to a very low level with as little as 4 pounds of a 6-percent gamma benzene hexachloride wettable powder per 100 gallons applied to the base and the trunk of peach trees early in October. A 10-pound dosage was also highly effective. This insecticide, as used, was more effective than either 2 or 5 pounds of a 25-percent parathion wettable powder per 100 gallons.

In Maryland a preliminary field test was made to determine the effect of the relatively pure isomers of benzene hexachloride, alone and in combination, on the odor and flavor of fresh, canned, and frozen peaches. No off-odors that could be attributed to any of these isomers were obtained, but the delta isomer showed the greatest tendency to cause off-flavor, followed by the beta isomer.

Good control of the oriental fruit moth with DDT was obtained in tests in New York, New Jersey, and Ohio. However, schedules that will give good control of moderate to heavy infestations are likely to leave excessive residues at harvest. The most effective schedule tried in New York included two applications of 2 pounds of 50-percent DDT per 100 gallons against the second brood and one application of 1 pound against the third brood. In Ohio best control was obtained with two applications of 2 pounds of 50-percent DDT per 100 gallons, the first application 8 weeks and the second 3 or 4 weeks before harvest. These schedules in New York and Ohio left residues in excess of 7 parts per million. In New Jersey, under conditions of heavy infestation, 2 pounds of 50-percent DDT per 100 gallons reduced injury to peaches by 17 to 100 percent, depending on the number and time of the applications. One or two applications of such a spray 3 weeks or more before harvest reduced fruit injury by about 50 to 60 percent, and harvest residues were below 7 parts per million. When more than two applications were made, however, with the last about 21 days before harvest, or applications were closer than 21 days to harvest, control was better but harvest residues were generally above 7 parts per million.

Parathion was extremely promising for oriental fruit moth control in New York, New Jersey, and Ohio. In New York ryania and

methoxychlor and in New Jersey chlordane and toxaphene were not promising.

Light infestations of the pear thrips on prunes in Oregon were controlled with parathion and with DDT both when applied to the ground before the overwintering adults migrated to the trees and later when applied to the trees. For application to the ground parathion was used as 0.5-, 1-, and 2-percent dusts and in sprays containing 2 pounds of 15-percent material per 100 gallons; and DDT was used as a spray at 2 quarts of a 25-percent emulsion concentrate per 100 gallons. For application to the trees, sprays containing ¼, ½, or 1 pound of 15-percent parathion per 100 gallons or 25-percent emulsible oil, 1–800, or dusts containing 0.5 or 1 percent of parathion or 5 percent of DDT were used. The sprays were applied to the trees when most of the green tips were showing in the blossom buds, the dusts 1 week later.

Effective control of the shot-hole borer in Washington was obtained with 2 pounds of 50-percent DDT or 1 pound of 25-percent parathion or benzene hexachloride (12-percent gamma) per 100 gallons when applied in time to kill the adults as they emerged.

Pecan insects

In tests against the hickory shuckworm on pecans in Georgia and Florida, both DDT and parathion reduced the number of premature drops by about 50 percent. The effect on the final yield, however, was masked by crop losses due to excessive rainfall and scab.

For control of the pecan nut casebearer a mixture of DDT and tank-mix nicotine bentonite gave the best results and also the greatest yield of nuts in Texas, but both parathion and toxaphene also showed promise. In northern Florida DDT at 2 pounds of 50-percent wettable powder reduced the nut casebearer infestation by 85 to 90 percent. The trapping of mature larvae, found promising as a means of timing spray applications in Texas, did not work out well in Florida. It was found, however, that the residual effectiveness of DDT will permit considerable latitude in the timing of sprays, since single applications made on different dates in comparable blocks during a 13-day period were about equally effective.

DDT continued to give good control of the pecan weevil in Texas and Georgia, and in Texas parathion and chlordane were found of value in preliminary tests.

Studies of the shoot curculios in Louisiana indicated that in good crop years the set of nuts is influenced more by cultural practices than by the attack of these insects. In 1948, when bloom was heavy, severely infested trees that were uncultivated set poor crops of nuts, whereas similarly infested trees that were cultivated set fair to good crops. Although benzene hexachloride and parathion sprays reduced the infestation of the shoot curculios, these reductions seemed to have little effect on final yields in 1948.

Citrus pests

The citrus red mite was controlled most effectively in Florida with wettable sulfur in combination with bis(*p*-chlorophenoxy) methane

and fairly well with a wettable sulfur-parathion combination. Both combinations have also given good control of the citrus rust mite.

In California sprays containing 1 to 2½ pounds of 25-percent parathion wettable powder per 100 gallons were satisfactory against the citrus red mite only when oil was included, when they held it in check between spring and fall applications. Aerosols containing acaricides applied under fumigation tents gave poor results in California. A yellowing and dropping of lemon leaves sometimes followed treatment with parathion alone or in combination with oil emulsions.

Pineapple mealybug

In tests conducted in Florida near Fort Pierce and North Miami, parathion dust was effective against the pineapple mealybug, the insect responsible for wilt disease of pineapples. Plants treated with a 1-percent dust at the rate of 0.35 ounce per plant were free of mealybugs for as long as 4 weeks after treatment. In another test 0.15 ounce per plant was not so effective as the heavier dosage, but a great reduction in the number of infested plants was evident for 11 weeks. Two applications of 0.16 and 0.24 ounce per plant 1 month apart were no better than one application of 0.16 ounce.

Only 0.01 part per million of parathion was found in samples of unpeeled whole pineapples 7 weeks after applications of 0.48 ounce per plant, and none was found in the flesh. None of the treatments were injurious to pineapple plants.

Grape insects

In tests in Ohio good control of the grape berry moth was obtained with 1½ pounds of 50-percent DDT wettable powder, with 2 or 3 pints of 25-percent DDT emulsion, and with 1 pound of 25-percent parathion wettable powder per 100 gallons, when applications were made at petal fall and in four cover sprays. Damage to berries by first-brood larvae was held to 3.2 percent or less and by second-brood larvae to 2 percent or less. DDT at ½- and 1-pound concentrations of 50-percent wettable powder seemed to be less effective than at 1½ pounds. In tests with a dust containing DDT and the fungicide ferric dimethyl dithiocarbamate, 12 applications gave control about equal to 8 spray applications. When first-brood control was omitted, 2 or 3 applications of a 5-percent DDT dust or 2 applications of a 2-percent parathion dust did not give acceptable control of the second brood, but 6 applications of a 5-percent DDT dust did give good control.

Parathion Promising for Control of Scale Insects

There are indications that an effective substitute for, or supplement to, oil for the control of scale insects on fruit trees has been found in the new insecticide parathion.

Experimental applications of parathion, as used for codling moth control in Indiana and for curculio control in Georgia, were extremely effective against the Forbes scale on apple and the San Jose scale on apples and peaches. The minimum effective dosage for control of these scales has not been determined, but one-quarter pound or more of 25-percent parathion per 100 gallons in six applications or one-half pound in three consecutive applications gave complete protection to

apples in Indiana and four applications of ½ to 2 pounds gave complete control on peach in Georgia. A single summer application of one-half pound of 25-percent parathion per 100 gallons gave partial control of Forbes scale on apples. During the dormant period, however, a single application of ¼ to 2 pounds per 100 gallons was ineffective against the San Jose scale on peaches, the control ranging from 41 percent for the higher dosage to none for the lower one.

Parathion showed promise for the control of scale insects on citrus. In Florida sprays containing one-half pound of actual parathion per 100 gallons gave good scale control whether prepared from wettable powders or emulsion concentrates. The indicated effectiveness of a parathion-wettable sulfur spray has given impetus to the efforts to develop a safe and effective combination spray to control the Florida red scale, purple scale, and citrus rust mite. At present materials recommended for combating these pests must be applied separately and only with a safe interval between applications.

In California parathion wettable powders appear to be at least as effective as conventional oil sprays against the California red scale, and the combination of ½ to 1 pound of 25-percent parathion wettable powder per 100 gallons with an oil spray has given even better results. Wetting agents did not increase the efficiency of sprays containing parathion wettable powders when used against the California red scale, and there was little advantage in increasing the concentration from 1 to 2½ pounds of the 25-percent wettable powder per 100 gallons. In California the percentage kill of scales was not affected by population density as it is when oils are used. Parathion appears to be somewhat more effective against scales on the old wood of citrus, whereas oil is generally most effective against scales on the new green wood and on fruit. Parathion caused a little injury to lemon foliage.

Parathion also gave almost complete control of the fig scale on fig fruit in California when applied early in May. From 10 to 20 ounces of 25-percent wettable powder per 100 gallons was used with a small quantity of summer oil.

Hall Scale Eradication

All trees in the Chico and Oroville areas of California known to be infested with the Hall scale were fumigated for the second successive year during the winter of 1948–49. For some trees this was the third or fourth annual fumigation. Although spot inspections have shown that a few scales can survive a single fumigation, no living scales have yet been found on trees fumigated more than once. As soon as trees fail to yield live scales after each of three successive annual fumigations, they will not be subjected to further treatment unless there is a recurrence of infestation. Inspections will be continued for at least 3 years after the treatment is discontinued.

A new infestation involving 10 properties containing 1,815 host trees was found in the vicinity of Bidwell Park at Chico in June 1949. Indications are that this infestation originated with the movement of plants from the Plant Introduction Garden at Chico.

No scales have been found in the orchard of the California Agricultural Experiment Station at Davis since the removal of infested trees and intensive treatment of remaining hosts nearby. This orchard was first found infested in October 1947.

No additional infestations of Hall scale were found in surveys, conducted in cooperation with State and local quarantine officials, of communities in California and elsewhere that had received shipments of host plants from infested areas at Chico or Davis.

This program is conducted in cooperation with the California Department of Agriculture.

Studies on Vectors of Stone-Fruit Viruses Begun

Studies to determine the insects responsible for the natural spread of the plant viruses that cause western X of peach and little cherry diseases in western United States were started in 1948. Field plots were established, and other facilities for the work, including a greenhouse, an electronic microscope, and an ultracentrifuge, were erected or installed by this Bureau or by cooperating agencies. Leafhopper suspects were given the most attention in the 511 transmission tests that were initiated.

This new Research and Marketing Act project is being undertaken in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the agricultural experiment stations of Utah, Washington, and Oregon. Headquarters are maintained at Riverside, Calif., and work is now under way at Logan, Utah, Wenatchee, Wash., and The Dalles, Oreg.

Comstock Mealybug at Low Ebb

During the middle and late 1930's the Comstock mealybug became a serious pest in many apple orchards in at least 10 eastern States extending from Connecticut to Georgia and west to include Ohio. Infestations were most numerous and injurious in Virginia. Since no insecticide was then known to be effective against this insect, work was undertaken at Charlottesville, Va., in 1940 to bring the infestations under control by the colonization of native and imported parasites. The apparent effectiveness of two parasites, *Allotropa burrelli* Mues. and *Pseudaphycus malinus* Gahan, imported from Japan and established throughout the infested area, and also of a widely distributed native parasite, *Clausenia purpurea* Ishii, was such as to reduce this mealybug to a pest of minor importance by 1945.

Soon after DDT became available, it was found to be highly toxic, not only to the young mealybugs, but also to the mealybug parasites. Despite the loss of effective parasites due to the use of DDT, the Comstock mealybug has been reduced almost to the vanishing point in orchards in which DDT has been used for codling moth control. In 1948 for the first time there were no calls for parasites for colonization, and surveys yielded only 3.2 mealybugs per man-hour in observation orchards, as compared with 27.5 in 1947. No mealybugs were found in any orchard in which DDT had been used more than one season.

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Reduction of the Comstock mealybug to a pest of noncommercial importance led to the discontinuance of the Charlottesville laboratory at the end of the 1948 field season.

Steps Taken to Combat Oriental Fruit Fly Menace

Owing to the seriousness of the oriental fruit fly problem in Hawaii and the potential importance of the pest should it reach the mainland of the United States, increased funds were made available for a study of this fly in cooperation with local agencies. Special attention was given to inspection and treatment of planes leaving Hawaii for the mainland and inspection of ships and passengers arriving at mainland ports. The use of vapor heat was authorized for the treatment of papayas and both vapor heat and methyl bromide fumigation for Vanda orchids prior to shipment.

In addition to regular funds for biological studies and experiments to find effective control measures, an extensive cooperative project in biological control was undertaken with funds authorized under the Research and Marketing Act. Natural enemies of this fly are now being sought in South Africa, Malaya, and India. Shipments of three species of parasites and one predator have been received from Malaya and of one species from the Philippine Islands, and about 70,000 parasites have been reared and released in Hawaii. Each of the parasites has been recovered at one or more points of release.

Further expansion of the program, in cooperation with several agencies in Hawaii and the State of California, is contemplated for the coming year. Five lines of research will be undertaken—(1) biology and habits of this fruit fly, (2) treatment of infested agricultural products so that they may be transported safely into uninfested areas, (3) search for insecticides that will kill the insect, (4) large-scale control and eradication experiments, and (5) biological control.

The oriental fruit fly situation in Hawaii is a typical example of what an insect pest can do when it gains access to a favorable habitat where its natural enemies are not present to check it. This fly is believed to have been brought to the Islands in fruit from Saipan in 1944 or 1945, but was first recognized there in 1946 in a mango grown in Honolulu. It has been found in more than 100 varieties of fruits and vegetables, in the blooms of one variety of Vanda orchids, and even in cotton bolls. Its favorite wild host is guava, which is abundant in Hawaii. Biological studies indicate that it has no hibernation stage, that it is long-lived—adults may live for 4 months—and that it is adaptable to a wide range of climate and altitude and could thus probably survive many climates on the mainland.

Sprays and Parasites Used Against the Citrus Blackfly in Mexico

Research directed against the citrus blackfly, which is a widespread and serious pest of citrus in Mexico, was continued in cooperation with the Mexican Government. The purpose was to find more effective means of controlling this blackfly in Mexico and thereby to protect fruit areas in the United States.

Field experiments with oil-cube and DDT sprays in Sonora, Mexico, greatly reduced blackfly populations in the vicinity of Empalme. Similar experiments in the Valles area in eastern Mexico indicate that the pest can be controlled in commercial groves with two spray applications a year. It was found that oil-cube sprays, although highly effective against larvae and pupae on the leaves, do not prevent eggs from hatching, but few of the larvae that emerge are able to mature.

In experiments with insecticide treatments of limes before shipment to the United States, pyrethrum mixtures showed the most promise. This work was conducted with funds authorized under the Research and Marketing Act.

One small air shipment of parasite material from Malaya was received at Colima, Mexico, during the year, and *Prospaltella* spp. was released in citrus groves. The search in Cuba for the effective predator, *Catana clauseni* Chapin, was unsuccessful.

Many citrus groves and most of the dooryard plantings in towns along the Mexican border were inspected during the year, but no infestations of the citrus blackfly were found.

Treatments to Kill Fruit Flies Permit Movement Under Quarantine

The Mexican fruit fly infestation in the regulated area of Texas was near normal during the early part of the harvesting season of 1948–49. Flies were beginning to appear and some larvae were found before January 29, when a hard freeze severely damaged the trees and much of the fruit. This abnormally cold weather apparently caused some delay in egg laying. As a result most of the fruit crop undamaged by the freeze was moved before the infestation built up to a point that required general sterilization. The new market that has opened up since Arizona and California have permitted the entry of citrus from Texas under Federal certification is expected to develop into an important outlet for high-quality grapefruit and oranges. Over 500 cars of citrus fruit were shipped from Texas to California this season under Mexican fruit fly certification.

The Bureau again assisted Argentine authorities in the development of equipment and facilities for the shipside precooling of fruit and for in-transit sterilization to kill larvae of the Mediterranean fruit fly. More than 300,000 boxes of deciduous fruit were thus treated during the 1948–49 season as a requirement for entry into the United States.

New Laboratory for Study of European Chafer

A study of the European chafer (*Amphimallon majalis* (Razoum.)), a foreign pest which feeds in the grub stage on the roots of field crops, grasses, and other plants, was begun in the spring of 1949. This insect was first recognized as a pest new to this country in 1942. It occurs in a limited area near Newark, N. Y. Since this insect might become a serious economic pest if it should become widely distributed in the United States, the New York Agricultural Experiment Stations recently requested this Bureau to participate in a cooperative investigation of the problem. Headquarters for the work are with the New York Agricultural Experiment Station at Geneva.

Parasites of Fruit Insects Exported

Shipments of natural enemies to foreign countries, either by the Bureau directly or in cooperation with State experiment stations, comprised several species of parasites of the San Jose scale to Italy; *Aphelinus mali* Hald., an enemy of the wooly apple aphid, to Mexico; *Rodolia cardinalis* Muls. to Bolivia for control of the cottony cushion scale; and *Trichogramma minutum* Riley, a general egg parasite, to Australia.

JAPANESE BEETLES

DDT Reduces Isolated Beetle Infestation

A large-scale experiment in the treatment of a well-established isolated infestation of Japanese beetles was carried on at Blowing Rock, N. C., from 1945 to 1948. When the work was started, the main area of infestation included about 250 acres of grub-infested turf, and scattered light infestations outside this area were found later.

In 1945 DDT was applied to practically all the turf in the main area of infestation at the rate of 250 pounds of 10-percent powder to the acre. Trees and shrubs in the area that were susceptible to beetle attack were sprayed once with DDT. During the next 2 years some of the low-growing shrubbery that was infested was treated with a hand duster.

As measured by the captures of beetles in traps, the treatment gave marked reductions in infestation. The approximate numbers taken in about 500 traps in the treated area for 5 years, beginning in 1944, the year before the treatment, were 139,000, 42,000, 20,000, 23,000, and 16,000. In contrast, the beetles captured in the lightly infested untreated area nearby increased from 357 in 1945 to 17,000 in 1948. In the absence of treatment the numbers would undoubtedly have increased in somewhat the same proportion throughout the entire area.

This experiment has shown that it is possible to reduce an isolated infestation to a very low point. With a more intensive soil-treating program and frequent application of DDT against the adult beetles, the population could undoubtedly be depressed much further.

Recommended Soil Treatments Injure Few Plants

DDT and chlordane do not appear likely to cause noticeable plant injury when applied to turf areas or to nursery soil at the rates recommended for control of Japanese beetle grubs. Records covering a 4-year period and at least 10.5 million plants grown in soils to which 25 pounds of DDT per acre had been applied in nurseries throughout the East, as well as records on many treated turf areas, indicate that most plants tolerate this amount of DDT. Nearly 1,700 varieties of plants, representing 957 species and 350 genera, have not been noticeably affected by such a treatment. Growth of onion, strawberry, tomato, lima bean, bush bean, spinach, and spring rye has been retarded

when these plants have been grown in soil treated with this dosage of DDT.

Chlordane has not been used so long or so extensively as DDT for control of Japanese beetle grubs, but most plants seem to tolerate the recommended dosage. When freshly applied, 10 pounds of chlordane per acre has had no noticeable effect on 7 varieties of azaleas or 21 varieties of evergreens grown in treated nursery soils, or on 11 varieties of grasses, 19 of garden vegetables, 2 of strawberries, and 18 varieties of annual plants, spring rye, soybeans, and hybrid corn in special tests. However, it has retarded the growth of celery, Massey strawberry, oriental poppy, and snapdragon plants.

Quarantine and Control Activities

Principal modifications in the regulatory program to prevent the spread of the Japanese beetle through the movement of infested host material consisted in an extension of the regulated area, provision for more flexibility in starting and terminating the seasonal quarantine on fruits, vegetables, and cut flowers, and approval of two new chemicals for treating plants and soil as a means of securing certification.

Additions to the regulated areas in Maryland, Virginia, and West Virginia were made on April 18, 1949. With these extensions there are now included within the regulated areas of these States all of Maryland, the eastern third of Virginia, and three more counties in West Virginia.

Another modification permits delay in establishment of the summer quarantine on fruits, vegetables, and cut flowers until actual appearance of adults or their known imminence in a particular locality. When such conditions are determined by on-the-spot observations of an inspector, the certification procedure can be started on short notice.

Aircraft was included in the revised regulations as a type of carrier subject to regulation.

An ethylene dibromide-chlordane dip for soil about the roots of plants was authorized September 21, 1948. With this treatment nurserymen are permitted to obtain certification for most of their stock on a year-round basis. Treatments have previously been available by which plants could be certified at all seasons except the summer period when beetle eggs are present. Eggs proved stubbornly resistant to insecticides tested until the ethylene dibromide-chlordane dip was developed.

Use of chlordane as an alternative treatment for bulk soil, surface soil, or ground planted with nursery stock was authorized on January 6, 1949. A dosage of 10 pounds of technical chlordane per acre applied in an approved manner is sufficient to qualify stock in treated areas for certification.

A total of 6,176 commercial and 6,484 military aircraft were given aerosol treatments to eliminate Japanese beetles during the 1948 season. The nonpassenger compartments of 421 commercial and 703 military aircraft were given, in addition, residual spray treatments. Supervision of these treatments was given at 37 airfields located in 9 States and the District of Columbia.

COTTON INSECTS

New Insecticides Effective Against Pests of Cotton

Investigations on cotton insects continued to center around the various new insecticides. Since most cotton growers must combat several pests at one time, and most of these materials are selective in the pests that they destroy, various combinations were tried to find one that would be suitable for the control of them all. The results of experiments conducted by Federal and State workers in 1948 were discussed at Baton Rouge, La., in November, at a conference on cotton insect research and control, as a basis for the preparation of recommendations for control operations during the ensuing season.

The tolerance of crops grown in soil containing various insecticides is being tested at Florence, S. C., in a 3-year crop-rotation experiment begun in 1947. Benzene hexachloride, alone and mixed with DDT, killed some cotton plants the first year, but none of the 1947 treatments had any effect on cotton stands grown in this soil in 1948.

Boll weevil

The boll weevil caused less damage in 1948 than in any year since 1944. Infestations were low during June and July, but changes in the weather later in the summer brought populations up to a very high level by the end of September.

The new organic insecticides showing most promise for the control of the boll weevil were benzene hexachloride and toxaphene. When either of these materials or calcium arsenate is used alone, however, infestations of other insects may develop. Therefore insecticides for their control should be included in the treatments.

In Texas the cotton farmers in four Wharton County communities participated in an experimental program for cotton-insect control. In three of these communities the most damaging insect was the boll weevil. Toxaphene in the form of a 20-percent dust was applied to 2,063 acres on 22 farms. Usually two applications gave control for the season. The dusted cotton retained its early squares, and the bolls matured at least 3 weeks before cotton in undusted communities nearby. The yield of lint cotton from 55 dusted fields was 448 pounds per acre, a gain of 138 pounds per acre over the yield from 33 undusted fields.

In Mississippi preliminary tests showed concentrated sprays applied by airplane at the rate of 2 gallons per acre to be superior to dusts containing the same amount of the same toxicant. The spray giving the best control contained 1.5 pounds of toxaphene plus 0.3 pound of chlordane in 2 gallons of emulsion. Other effective formulations contained 1 pound of chlordane, 2 pounds of toxaphene, or sufficient technical benzene hexachloride to give 0.3 pound of the gamma isomer. Sprays cost no more to apply, and they can be applied under more varied weather conditions and during more hours of the day.

In South Carolina dusts containing toxaphene, benzene hexachloride plus DDT, or chlordane plus DDT gave about the same degree of boll weevil control and increased the yield of seed cotton approximately 100 percent. Sulfur was included for mite control in all these dusts.

Bollworm

The bollworm is one of the most difficult cotton insects to control. Timeliness of application and thorough coverage with the insecticide throughout the period of infestation are especially important in connection with this pest. DDT and toxaphene are both effective against the bollworm, but DDT alone will not control certain other cotton pests and aphids increase after its use.

In Texas a dust containing 10 percent of DDT and sufficient benzene hexachloride to give 2 percent of the gamma isomer controlled bollworms better than 20 percent of toxaphene or 5 percent of DDT plus benzene hexachloride to give 3 percent of gamma.

In 1948 serious outbreaks of this insect occurred in Texas, Oklahoma, New Mexico, and Arizona. Large acreages were dusted with the new organic insecticides, and satisfactory results were usually obtained when they were applied at the proper time.

Cotton aphid

Since aphid infestations often follow the use of insecticides for the control of other cotton insects, all dusts for use on cotton should contain a toxicant for aphids. Experiments in several States indicate that benzene hexachloride or parathion will control cotton aphids if applied at the proper time. Evening applications of benzene hexachloride were more effective than morning applications. A dust containing benzene hexachloride, DDT, and sulfur gave satisfactory control of the cotton aphids as well as boll weevils, bollworms, and spider mites. Toxaphene applied against weevils and bollworms also controlled cotton aphids.

In the tests with concentrated sprays in Mississippi, excellent control of cotton aphids was obtained with tetraethyl pyrophosphate at 0.1 pound and adequate control with benzene hexachloride at 0.3 pound of the gamma isomer per acre. The sprays were applied at 3:30 in the afternoon, when the temperature was 80° F. and the wind velocity 12 miles per hour.

Pink bollworm

DDT continues to be the best insecticide for control of the pink bollworm. Dusts should be applied every week in sufficient quantities to give 1.5 to 3 pounds of technical DDT per acre. Benzene hexachloride and sulfur should be included to prevent build-up of other cotton insects and mites. Thorough coverage of the cotton plants is important, and when the dusts are applied by airplane the swaths should not be more than 45 feet wide.

Although the pink bollworm is now confined to four southwestern States and Florida, the results of survival tests in Texas in 1948 emphasize the importance of continuing strong measures to prevent its spread. In the winter of 1947–48 the pink bollworm survived a temperature of −6° F., and moths emerged in south Texas as long as 12½ months after the larvae entered hibernation.

Salt-marsh caterpillar

The worst outbreak of salt-marsh caterpillars ever known occurred in the Salt River Valley of Arizona in the fall of 1948. Much of

the cotton in that area was defoliated. Farmers were forced to trench around infested fields and fill the ditches with water to prevent the caterpillars from moving into other fields. In field experiments Bureau entomologists found that a dust mixture containing toxaphene, DDT, and sulfur reduced the infestation to a very low point. This is the first insecticide material ever found to give good control of these caterpillars on cotton.

Other cotton insects

Toxaphene, benzene hexachloride, DDT, and mixtures of these insecticides, found to give good control of the principal cotton insects, were also effective against the cotton fleahopper and plant bugs. In the fourth community in Wharton County, Tex., that was included in the cooperative experiment for control of cotton insects, the fleahopper was the most damaging pest. A total of 4,141 acres on 47 farms were dusted twice with 10 percent of toxaphene. The effect on fruiting and maturing of the bolls was the same as in the other communities, and the yield of lint cotton showed a gain of 110 pounds per acre over that in an undusted community nearby.

In experiments in Arizona benzene hexachloride, DDT, and toxaphene were about as effective against plant bugs when applied in concentrated sprays as in dusts. Against stink bugs benzene hexachloride was more effective than the other two insecticides.

Serious damage from the cotton fleahopper in 1948 was confined largely to the Gulf coast section of Texas and the Santa Cruz Valley of Arizona. Plant bugs and stink bugs on cotton in the irrigated sections of the Southwest were less abundant than in any recent year.

Progress Made in Basic Research on Cotton Insects

Research to determine the fundamental factors governing the effectiveness of various measures for controlling insect pests of cotton was conducted in Texas and Mississippi with funds authorized by the Research and Marketing Act of 1946. These factors include reactions of insects to different control measures and the reactions of the plant to insect attack and to the insecticide. Studies were made with a large number of new insecticides and combinations of insecticides, chiefly under laboratory or cage conditions. During the year it was demonstrated that both benzene hexachloride and parathion are compatible with calcium arsenate low in free lime and that the essentially pure gamma isomer of benzene hexachloride is less compatible than the technical grade containing several isomers. Evidence was obtained that the new insecticide known chemically as octamethylpyrophosphoramide is absorbed by cotton plants in sufficient quantity to kill red spider mites.

Pink Bollworm Quarantine Activities

Results of inspection

Intensive inspections of the 1948 cotton crop for the pink bollworm were carried on within regulated areas of Arizona, New Mexico, Oklahoma, and Texas, and outside the regulated areas in these and other

cotton-growing States. Only three counties were found infested for the first time—Quay in New Mexico and De Witt and Crockett in Texas. All were adjacent to known infestations. Infestations were found in 40 new counties in 1947. In Florida there has been a decided increase of infestation on wild cotton since eradication of these plants has been discontinued.

Within regulated areas inspections in 54 counties of Arizona, New Mexico, Oklahoma, and Texas were negative. Inspections of cotton blooms early in the 1948 season revealed infestations in southern Texas capable of developing high populations.

Inspections of gin trash in Texas revealed a considerable increase in pink bollworm populations over the previous year in Cameron, Hidalgo, Willacy, Starr, Jim Hogg, Brooks, Zapata, Webb, Duval, Jim Wells, Kleberg, Nueces, and Maverick Counties. San Patricio and Calhoun Counties showed less infestation than in 1947. None was found for the third consecutive season in Brazoria, Chambers, Liberty, Orange, Jefferson Counties and the regulated portion of Harris County, and they have been released from the quarantine. Inspection results were negative for the second successive year in Jackson, Matagorda, and Wharton Counties.

Inspections in August 1948 showed an infestation in blooms in Howard County, Tex., the first record of pink bollworms in blooms in that area. Subsequent inspections of gin trash disclosed a considerable infestation in Andrews, Gaines, Martin, Midland, and Howard Counties, and the western half of Mitchell County. Infestation in the remainder of northwestern Texas was much lighter, and many counties found infested in 1947 were apparently free this year. Infestation recurred in only Mills and Hamilton of the eight counties of central-west Texas placed under quarantine in the fall of 1947.

Thorough inspections were negative in the eight southwestern Oklahoma counties placed under quarantine in 1947. Inspections in Arizona were negative except for continued light infestations on the eastern border. There was little change in infestation in the irrigated valleys of New Mexico and western Texas. In 53,500 bushels of gin trash from the 1948 crop in regulated areas of Arizona, New Mexico, Oklahoma, and Texas, 268,400 pink bollworms were found, principally in Texas. In the field nearly 12,000,000 bolls, blooms, and squares were inspected in Arizona, New Mexico, and Texas, and 23,600 pink bollworms were found, all in Texas with the exception of 1 in New Mexico. In addition, 8 Thurberia weevils were found in bolls in Arizona.

Inspection of 36,900 bushels of gin trash from areas outside regulated territory plus 916 bushels in Mexico yielded 6 pink bollworms, 3 each from Texas and New Mexico. From 3,600 bolls, blooms, and squares examined in fields of free areas in Arizona, New Mexico, and Texas, 1 pink bollworm was found in Texas.

Control operations

Dusting to control the pink bollworm was performed in three heavily infested sections in the summer of 1948—in 9 southern Texas counties, 135 fields totaling 5,639 acres; in Howard County, northwestern Texas, 9 fields of 490 acres; and in Mexico adjacent to the border,

69 fields of 2,514 acres. Approximately 535,000 pounds of dust containing 10 percent of DDT, sufficient benzene hexachloride to give 2 percent of the gamma isomer, and 40 percent of sulfur were used. These fields received from one to six dustings, depending upon the infestation and fruiting of the plants. High, dry winds prevailed while much of this work was in progress. Consequently results were not so favorable as desired, although some build-up of infestation in early bolls was prevented. Since drought prevented the setting of late bolls in many of the fields in dry-land areas, the benefits may have been considerable.

Whereas these control programs are intended to suppress outbreaks of the pink bollworm and thus prevent spread of the pest, they also serve as demonstrations of the value of such work by individual growers. In the heavily infested Presidio Valley of Texas, for example, growers who saw the work there are now using the same methods and are obtaining good results.

Four thousand tons of planting cottonseed were treated in a Federal-State cooperative program in Texas, principally for growers in Andrews, Gaines, Midland, Martin, and Howard Counties, and the western part of Mitchell County. This program supplemented the dusting program undertaken there to suppress the serious infestation that developed in 1947 and 1948.

Compliance with State field clean-up requirements in the Lower Rio Grande Valley of Texas was incomplete, as over 30 growers there were charged with violation of the State pink bollworm law. However, that number is a very small percentage of the 6,343 growers who planted cotton under permit on 600,854 acres.

Estimates of increased yield in the Lower Rio Grande Valley place a value of more than $10,000,000 annually on the incidental benefits from control of other cotton insects, particularly the boll weevil, resulting from the rigid cultural practices required for pink bollworm control. Before the value of establishing a host-free period was accepted by the growers, it was necessary to use public funds to remove volunteer plants, but now many growers are using thousands of man-days of labor each fall to grub out volunteer cotton while others may replow several times in order to kill all sprouting cotton. Examination of crop residues on the soil surface in a number of fields in southern Texas in March and April of 1949 revealed living pink bollworms in seed in old cotton bolls. Failure of the growers to cover such residues by plowing deep enough to prevent emergence of overwintering pink bollworms is responsible for this survival. The cleaning of cotton fields by certain dates was also required by State regulation in the other quarantined areas in southern Texas, and on the whole a satisfactory pink bollworm host-free condition was maintained, although a number of growers were delayed beyond the stalk-destruction deadline by reason of excessively wet fields.

The State of Arizona again prohibited the growing of stub cotton in the southern and eastern portions of the Salt River Valley. The Bureau participated in locating and removing stub-cotton plants to prevent the pink bollworms from having an early supply of food.

Regulatory operations

Investigations on the fumigation of cottonseed in steel tanks of 10,000 to 54,000 cubic feet, and holding up to 600 tons of seed, were completed, and the method was approved for commercial use for elimination of the pink bollworm. In all 18,000 tons of seed were treated in this way during 1948. Forced circulation of gas through the tank insures its effective distribution throughout the load in 5 to 10 minutes.

The pink bollworm quarantine was amended on April 27, 1949, to add to the lightly infested area several counties of New Mexico and Texas found infested during the 1948 season and to release from quarantine six counties in Texas in view of their apparent freedom from infestation for several consecutive years.

The extension of the pink bollworm quarantine in northwestern Texas and southwestern Oklahoma in the fall of 1947 added a tremendous cotton-growing and ginning area to that already under pink bollworm regulation. During the current fiscal year inspectors made 54,463 visits to 1,267 gins, 70 oil mills, and 105 compressers, as well as other handlers. A total of 316,532 permits were issued covering movement of cotton and its products. Recent simplification of issuance of permits makes it possible for an inspector to supervise 30 to 40 cotton-processing units in northwestern Texas and southwestern Oklahoma, whereas under the old permit system 3 or 4 inspectors would be required for that number of units.

More than 2,700,000 bales of cotton were ginned under dealer-carrier permits in Texas, New Mexico, Arizona, and Oklahoma. Nearly 1,150,000 tons of seed were given one heat treatment, 73,600 tons were given a second heat treatment, 24,000 tons were fumigated with methyl bromide, and nearly 1,000,000 tons were received at oil mills. Nearly 2,800,000 bales of lint and linters were compressed, and nearly 10,000 bales of lint and linters from Mexico were vacuum-fumigated.

At the three stations maintained to inspect highway traffic from the quarantined area in the Lower Rio Grande Valley, 477,850 cars and trucks were inspected and 4,659 found carrying contraband material.

Cooperative work with Mexico

The cooperation of cotton growers and owners of processing plants in Mexico has improved with respect to cultural controls in the fields and treatment procedures at processing plants. In the Laguna area growers used 35 airplanes to apply insecticides for control of pink bollworm and other insects, as compared with 1 plane 3 years ago.

The cotton planted in the Matamoros area increased to more than 600,000 acres in 1949. The presence of this large acreage adjacent to the Lower Rio Grande Valley requires joint effort of the two countries to control the pest. Established planting and stalk-destruction dates in the Matamoros area parallel those applicable in the Rio Grande Valley of Texas. Enforcement is about equal in each country.

By rendering technical assistance in Mexico on this common problem, the cotton industry of the United States receives greater protection than would be the case if all work against this insect were carried on solely in the United States.

CEREAL AND FORAGE INSECTS

Grasshoppers

Control programs in 1948 protected extensive crop and range lands

In the summer of 1948 farm crops worth $68,000,000 were saved by grasshopper control programs. Nearly 8,700,000 acres of crops and pasture lands were protected from these pests by various measures. It cost the cooperating agencies $1,914,000 to conduct baiting operations during the year. The program saved about $55 for each dollar spent, exclusive of farmer-rancher services.

In addition to the cooperative baiting program, two types of control operations were conducted by the farmers and ranchers themselves. Many of them purchased chlordane, toxaphene, or benzene hexachloride, which they applied as sprays or dusts. About 1,400,000 acres in 20 States were treated in this way in 1948 at a cost of nearly $4,000,000 for insecticides alone. A voluntary baiting program was also conducted by more than 46,000 farmers and ranchers in 22 States. More than 17,000 tons of sodium fluosilicate bait, furnished by the Federal Government, were spread on 3,200,000 acres. This Bureau also financed spreading an additional 1,650 tons of bait and applied 35,000 gallons of spray on roadsides, pastures, and rangelands in 9 States. These operations included large-scale experiments in 4 States.

In spite of the unparalleled scale of these control operations and the excellent control obtained, losses to grasshoppers in 1948 were the highest since 1939. Conservative estimates placed crop losses at $37,000,000, and damage to range land was extensive.

1949 outbreaks fought with new baits applied by airplane

A progressive increase in numbers, especially of the lesser migratory grasshopper, throughout the western Plains States from Texas to Canada has been noted for several years. By the fall of 1948 about 5 to 6 million acres of range land as well as large agricultural areas were heavily infested with about 25 species. Surveys at that time indicated that the infestation would be even more widespread in 1949, and that the migrations into cultivated areas would be heavier unless aggressive measures were taken.

Weather conditions in the spring of 1949 favored grasshopper development so that the infestations were even heavier than had been expected, and on a few million acres in Montana and Wyoming the situation was especially critical. To meet this emergency a special control program was conducted in cooperation with State and county agencies and property owners.

Bait containing toxaphene or chlordane as the toxicant was distributed from aircraft, both Government-owned and contract. The operations were begun on June 5, while the grasshoppers were in the nymphal stage and before they could migrate to range and crops on noninfested areas. At first the bait was applied at the rate of 5 pounds per acre, but later it was found necessary to use heavier dosages in some areas to obtain maximum kill of the adults. Ranchers and farmers outside but near the treated areas were furnished bait for dis-

tribution by privately contracted planes or by other types of bait-spreading apparatus.

Grasshopper infestations were also unusually heavy in other parts of the country. Another migratory species that has caused some injury to stock range in Nevada and has been moving westward and northward for several years had infested more than a million acres in California and Oregon by the end of June 1949.

The Bureau's participation in cooperative programs for control of grasshoppers was changed somewhat in 1949. Since chlordane and toxaphene have been found effective against grasshoppers when applied as sprays or dusts, and are now readily available, farmers have a means of protecting their own crops when only local infestations are involved. In such cases it is suggested that the farmer procure and apply his own insecticides, although the Bureau and the States will assist in providing information and advice. In large-scale infestations and emergency outbreaks on croplands, the extent and type of Bureau participation are determined by such factors as value of crops, the extent of public lands, the need for special equipment, and technical personnel required. If after conference with State leaders Bureau assistance is deemed advisable, aid is given to the extent that personnel, funds, and equipment are available.

Chlordane and toxaphene new weapons to combat hoppers

The new baits used this year were recommended after several years of research in the Bureau. They consisted of 100 pounds of coarse bran impregnated with ½ pound of chlordane or 1 pound of toxaphene in ½ gallon of kerosene. These dry baits have the advantage that they can be prepared well in advance of use and stored until needed. They can be applied with single-outlet dusters as well as by airplane, but the machines used for broadcasting wet baits are not equipped to apply such small dosages uniformly.

Chlordane or toxaphene can also be used in the standard wet bait. When used at the same strengths as in the dry baits, they have consistently given better kills than 6 pounds of sodium fluosilicate. Emulsion concentrates and wettable powders are the most practical preparations for use in wet baits.

Sprays and dusts containing chlordane or toxaphene have given good control in dense, succulent vegetation, but bait is more economical and just as effective on range land, grain stubble, fall-seeded grain, and dry vegetation that is no longer attractive to grasshoppers as food.

Mormon Cricket Damage Slight on Crops and Range

As indicated by the surveys, Mormon cricket infestations were less extensive in 1948, the infested acreage being the smallest in the last 12 years. Control was required in only 11 counties in Idaho, Nevada, Oregon, and Washington. In the Federal-State cooperative program Bureau personnel spread 1,883 tons of bait on about 189,000 acres. Nine-tenths of this acreage was baited with ground equipment, the remainder by airplane. An additional 251 tons was spread by farmers, ranchers, and other cooperators on 21,500 acres. Crop damage was slight, owing to early and adequate control and to the fact that most

infestations were on range far removed from cultivated lands. Damage to pasture and range was about 10 percent on about 230,000 acres.

In 1948 it was expected only a few areas in two or possibly three States would need control. By June 25 Bureau crews had spread 145 tons of bait on 55,300 acres in Oregon and Washington, and cooperators had spread an additional 12 tons on 4,742 acres.

Chinch Bugs and Cutworms Require Little Control

Chinch bug populations continued to be low in the Central and Midwestern States. Control was required on only a few scattered farms in 20 counties in Missouri and Oklahoma, where 9,300 gallons of federally provided creosote oil were used to maintain barriers for the protection of their crops in 1948.

A survey during the fall and early winter of 1948 in 153 counties of 7 States indicated that, unless weather conditions were unusually favorable for the bugs the following spring and summer, an outbreak would not be probable. By late June 1949 there were still no indications that chinch bugs would be a problem in other than a few localities.

Cutworm infestations were of concern to farmers during 1948 only in limited areas of a few States. Farmers in 21 counties of 6 States used bait provided by the Federal Government to control the bugs. About 40 tons of bait were spread on 6,725 acres of crops infested with bait-controllable worms, mainly the armyworm and army cutworm. During the spring of 1949 infestations requiring farmers' attention developed in scattered areas of Arkansas, Colorado, Kansas, Minnesota, Missouri, Oklahoma, Oregon, South Dakota, Texas, and Wyoming.

Cotton Bags Made Insectproof

A method of treating cotton bags to keep insects out of flour or other milled cereals packed in them has been developed in cooperation with the Bureau of Agricultural and Industrial Chemistry and commercial insecticide and cotton-bag manufacturers. The investigations were financed in part by funds authorized under the Research and Marketing Act of 1946. The insect repellent, which consists of pyrethrins or a mixture of pyrethrins with piperonyl butoxide, can be applied to the warp yarn in the usual sizing treatment before the cloth is woven or to the cloth by the padding method before the bags are made. The appearance of the treated fabric is not materially changed, a slight odor imparted by the chemicals is not objectionable, and baking tests conducted at Kansas State College indicate that the quality of flour stored in treated bags is not affected.

The efficiency of the treatment was tested by exposing small bags, both treated and untreated, containing insect-free flour for long periods in a room heavily populated with confused flour beetles, cadelles, Mediterranean flour moths, lesser grain borers, and other insects that are able to penetrate or deposit their eggs through the fabric of untreated bags. Very few or no insects penetrated treated bags during

a 7-month period, whereas 563 insects penetrated one of the untreated bags.

Pyrethrins and piperonyl butoxide are much less harmful than most insecticides to man and livestock. Although it seems unlikely that, at the rates and methods of application used, products packed in treated bags will be contaminated, further work is needed to answer this question and also to determine minimum effective rates of application. Results thus far indicate that the cost of the treatment will not be prohibitive. It also appears promising for use on containers made of other materials such as cardboard and paper.

European Corn Borer Continues to Spread

In 1948 the known distribution of the European corn borer, as determined by the annual fall survey in cooperation with interested State agencies, was extended by 116 counties. One borer was found in St. John the Baptist Parish in Louisiana, approximately 450 miles from the nearest known infestations in Tennessee and Missouri. Of the other newly infested counties 35 were in Missouri, 34 in South Dakota, 20 in Nebraska, 3 in Kentucky, 2 in Minnesota, 2 in North Dakota, 1 each in Kansas and Michigan, 7 in Tennessee, and a total of 10 in Maryland, West Virginia, Virginia, and North Carolina.

In the North-Central region there was little change in borer abundance in 1948 compared with 1947. Populations remained about the same in Indiana and Illinois. Decreases in Minnesota and Wisconsin were more than offset by increases in South Dakota, Nebraska, Iowa, Missouri, and Ohio. In the Eastern States the borer was at least as abundant as in 1947. The losses of grain corn caused by it were estimated to be about 85,485,000 bushels, or about twice as great as in 1947, and were valued at $99,107,000. With an additional loss of sweet corn valued at $4,129,000, the estimated losses caused by the borer in 1948 amounted to $103,236,000.

In Iowa experiments were conducted with different methods of applying DDT to field corn. Sprays applied with ground equipment were the most effective, dusts applied with ground equipment were next best, and sprays and dusts applied by airplane were poorest. One application, if properly timed, was about as effective as two. Two applications with ground equipment 7 days apart, at 1.2 pounds of DDT in 32 gallons of water per acre-application, increased the yield in the treated portion of a field by 15 bushels per acre over that in the untreated portion, where the infestation averaged 246 borers per 100 stalks. In comparison, a 5-percent DDT dust applied with ground equipment at the excessive rate of 3.25 pounds of DDT per acre-application on the same dates and in the same field increased the yield only 9.7 bushels per acre.

Parasites of European Corn Borer and Sweetclover Weevil Imported

Shipments of European corn borer parasites from France during the year consisted of 2,867 cocoons of *Campoplex alkae* E. and S., 975 cocoons of *Microgaster tibialis* Nees, and 54,000 field-collected corn

borer larvae, some of which contained small larvae of *Apanteles thompsoni* Lyle.

Small shipments of two parasites of the sweetclover weevil from Europe were received at the North Dakota Agricultural Experiment Station for rearing and colonization.

Benzene Hexachloride and Parathion Control Greenbugs

In preliminary tests conducted in cooperation with the Oklahoma Agricultural Experiment Station, benzene hexachloride dusts containing 3 and 5 percent of the gamma isomer applied to winter oats at 12 pounds per acre gave excellent control of greenbugs for several weeks. A 3-percent hexaethyl tetraphosphate dust and a dust containing 5 percent of DDT and sufficient benzene hexachloride to give 2.5 percent of the gamma isomer also gave good initial control, but within 3 weeks the infestation was higher than before the insecticides were applied. Dusts containing lower percentages of the gamma isomer of benzene hexachloride, 5 percent of DDT, or 1 percent of rotenone gave poor control as compared with the benzene hexachloride and hexaethyl tetraphosphate treatments.

Two-percent parathion dust was at least as effective as benzene hexachloride dust containing 3 or 5 percent of the gamma isomer. Preliminary tests have also indicated that barley plants will translocate parathion from treated soil to the leaves in sufficient quantities to kill greenbugs for 5 to 6 weeks after treatment.

Toxaphene Effective Against Meadow Spittlebug

During the last few years the meadow spittlebug has seriously injured legumes and other plants in the Eastern and Lake States, and has interfered with blossom formation and seed setting in alfalfa. In Wisconsin spittlebug infestations have been increasing in severity and extent for more than 10 years. In experiments conducted in cooperation with the Wisconsin Agricultural Experiment Station, good control was obtained with insecticidal sprays applied at low pressures and low gallonages per acre. Toxaphene, either in emulsion or in water suspension, appeared to be the best material tested, being effective at a dosage of as little as 1½ pounds per acre. Chlordane at 1 and 2 pounds per acre in emulsions and suspensions was also effective, but not so uniformly so as suspensions and dusts of this insecticide were in 1947. Suspensions of benzene hexachloride containing 5 percent of the gamma isomer applied at the rate of 1½ pounds of the technical material per acre and a DDT emulsion at 1 pound of DDT per acre have shown some promise. Parathion as a water suspension at one-quarter pound of the technical material per acre gave little control.

New Insecticides Control Southern Corn Rootworm in Peanuts

The southern corn rootworm has recently been causing heavy losses of peanuts in Virginia and North Carolina. In some years as many

as 80 percent of the pods on heavy, poorly drained land have been damaged. In experiments at Holland, Va., in cooperation with the Virginia Tidewater Field Station, significant control of this pest was obtained with organic insecticides broadcast by hand over the soil of small plots and raked into the upper 1 to 2 inches. Benzene hexachloride was effective at 1 pound of the gamma isomer, parathion at 5 pounds, toxaphene at 40 pounds, and DDT at 67 pounds per acre. Applications made early in June were more effective than those made a month later.

Foliage applications of benzene hexachloride, chlordane, toxaphene, and parathion, in either dusts or emulsions, also gave good control of this rootworm in small-plot tests at Holland, Va., and Beltsville, Md.

Despite these promising results on small areas, none of the insecticides or methods of application are recommended for use by growers until more is known about methods and time of application, the effect on plant growth in various types of soil, and the possibility of undesirable residual effects on peanuts or on crops grown in rotation with peanuts.

WHITE-FRINGED BEETLES

Soil and Foliage Treatments with DDT Subdue Beetles

Soil and foliage treatments with DDT have continued to be highly successful in combating and preventing the spread of white-fringed beetles. Few new areas of infestation have been uncovered in the past year, the most important being in Memphis, Tenn. Although the beetles are now known to occur in eight southern States on approximately 220,000 acres of land, only a part of this acreage is heavily infested and serious crop damage is encountered only occasionally. The development of new insecticide formulations and new procedures and equipment for applying them has contributed to the effectiveness of this control program, and has also markedly lowered the cost of operations. Large-scale application of DDT by airplane has been an important factor.

Nurseries in or near the infested areas have quickly and widely adopted the authorized use of soil applications of DDT at the rate of 50 pounds per acre. This procedure, when accompanied by a series of foliage spray applications at 0.5 to 1 pound per acre in the environs during the period of beetle emergence, promises after the second season to assure against beetle dissemination in stock from treated nurseries. There has been no evidence of injury to the plants from this heavy soil treatment.

Soil treatments with DDT at 10 pounds per acre are being applied with State cooperation to farm land having high beetle populations. Where soil treatment is impractical or there is special danger of spread, several foliage applications of DDT through the adult beetle season are made.

Effect on Plants of Various DDT Formulations Used to Control White-fringed Beetles

Field tests were made to determine the effect on various plants of DDT foliage sprays applied for the control of white-fringed beetles. No injury to any of the plants, which included sweetpotatoes, peanuts, cotton, crowder peas, squash, soybeans, corn, and sorghum, was detected from DDT emulsion applied at 2 pounds of DDT per acre. When sweetpotatoes, cotton, crowder peas, and soybeans were evaluated as to yield, no significant difference was found between any treated crop and its check plot.

From July through November 1948, 17 ornamental nurseries in Alabama, Mississippi, and Louisiana were visited periodically to record any plant injury resulting from the treatment of the soil with 50 pounds of technical DDT per acre in 1947 or 1948, and in 11 of these nurseries any injury to foliage from applications at the rate of one-half pound of technical DDT per acre made at 2-week intervals throughout June, July, and August 1948. Observations were made on 706,555 ornamental plants representing 84 genera, 131 species, and an undetermined number of varieties. These plants included 155,938 azalea plants representing 6 species and 49 varieties, and 263,966 camellia plants of 2 species and 347 varieties. No injury to any plant from the use of DDT was observed. Some complaints were made by growers that a plant had been injured. In each case, however, obvious factors, such as inadequate drainage, improper care, unsatisfactory soil conditions, sunscald, shade, diseases, and insect pests, were established as causing the condition of which the nurseryman complained.

DDT foliage sprays have been used regularly for the control of white-fringed bettles since 1946. In 1948, 25,000 acres were treated with emulsion or suspension sprays at a rate equivalent to ½ to 1 pound of technical DDT per acre. No garden, truck, or foliage plants were included in the spray schedule; however, no injury from spraying to cover crops to be turned under or to native vegetation was observed.

CHEMICAL STUDIES OF INSECTICIDES

New Insecticides Similar to Pyrethrum Made Synthetically

Chemicals almost identical with the natural insecticidal principles in pyrethrum flowers have been synthesized in the laboratory. This achievement is the culmination of about 15 years' investigations on the chemistry of pyrethrum by chemists of this Bureau. The compounds responsible for the insecticidal properties of pyrethrum are esters known as pyrethrins. The newly synthesized compounds are closely related to one of these esters. They have the same knockdown, or paralyzing, effect on insects, and indications are that they will not lose their insect-killing value so quickly as the natural material. One of these compounds, or pyrethroids, has been found in laboratory tests to be several times as toxic to house flies as the combined active principles of pyrethrum flowers. The toxicity of the synthetic products to higher animals is being investigated.

The commercial synthesis of the pyrethroids is now being investigated. If the process proves feasible, the United States will no longer be dependent on imports of pyrethrum flowers, which have amounted to as much as 20,000,000 pounds in 1 year. Pyrethrum is a strategically important material, which is now obtained entirely from foreign sources. Owing to the need for large quantities by the armed forces during the war, there was a critical shortage of pyrethrum for agricultural uses. Although many synthetic organic insecticides have been developed in recent years, prior to the synthesis of these pyrethroids, no satisfactory substitute for pyrethrum insecticides had been found for certain uses.

Chemical Methods for Parathion Developed

A method has been developed for purifying parathion in order to obtain material for use as a standard in analytical work or other investigations. Technical parathion is washed with petroleum ether and then dissolved in ethyl ether. The ether solution, after being washed with 10-percent sodium carbonate solution, is passed through a short column of adsorbent clay and diatomaceous earth. The resulting oil is taken up in a mixture of petroleum ether with ether and crystallized by chilling. The purified product is an odorless, yellow oil, which crystallizes readily in needles that melt at 6° C.

A polarographic method of analysis has been developed for the assay of technical parathion and formulations containing it. Electrolysis is carried out at 25° ±0.5° C. in an acetone-water solution with 0.05N potassium chloride as the electrolyte and 0.01 percent of gelatin as the suppressor. A saturated calomel electrode is used as the reference electrode. About 10 milligrams of parathion is needed for final analysis.

Insecticidal Amide Isolated from Prickly-Ash

An insecticidal compound has been isolated from the bark of the southern prickly-ash tree and identified as N–isobutyl–2,8–dodecadienamide. This amide, which has been named "herculin," is similar chemically to affinin, an insecticidal compound previously isolated from the roots of *Heliopsis longipes* (A. Gray) Blake, a Mexican herbaceous plant known locally as chilcuague. It is unusual to find constituents similar from both chemical and insecticidal standpoints in plants of such different types.

Three other species of *Heliopsis* occurring in the United States were shown to have insecticidal properties, and studies are under way to determine their active constituents.

These studies were conducted with funds authorized under the Research and Marketing Act of 1946.

Diluents for Insecticides Sought in Agricultural Waste Products

A number of agricultural waste products, including nutshells, seed hulls, and bark and other residues from forest and field crops, have been tested for potential usefulness as diluents for insecticide dusts.

The nutshells examined were almond, coconut, filbert, pecan, and walnut. Forest products included redwood and southern pine bark, wood flour, and sumac leaves. Other materials were peach and apricot pit shells, rice hulls, peanut shells, corncob fractions, corn stover, flax shives, hemp hurds, wheat straw, tobacco dust, and residues from castor-oil filtration. There are indications that when finely ground these plant materials are more uniform in particle size than the mineral diluents now used for insecticides. DDT wettable powders prepared with some of these materials as diluents are also being tested. These studies are conducted with funds provided under the Research and Marketing Act of 1946.

METHODS OF DISINFESTING AIRCRAFT IMPROVED

A combination of residual and space treatments has been found experimentally to aid in preventing insects from hitchhiking by airplane. Residual insecticides, applied in carbon-dioxide-propelled solutions, remained toxic longer than the period of the air trip, but did not leave an unsightly deposit or have an injurious effect on the surface material. Space aerosols, released in fixed installations in the plane, gave further protection because the fine particles penetrate even the small cracks and crevices where insects can stow away.

The automatic equipment for dispersing these aerosols, modified and perfected by the Bureau in cooperation with several other governmental agencies, has now been tested under operating conditions. The apparatus consists of a centrally located aerosol supply tank connected to a manifold system of aluminum or copper tubing, with outlets for nozzles located at suitable places in the interior of the plane. The flow of liquid is controlled with solenoid valves, and the dosage is regulated by a mechanical timing device. Dispensers have been installed in two planes of the Military Air Transport Service operating out of Honolulu, and on July 1, 1948, had given satisfactory service for 6 months.

WORK ON MECHANICAL DEVICES FOR USE IN PEST CONTROL COORDINATED

Recent coordination in the development and use of machinery and other devices in plant-pest control has resulted in the general improvement of several important pieces of equipment and in the design of two entirely new items. This activity also afforded means of advising field stations on the availability and proper use of special machines and thus eliminated much independent investigation and consequent duplication of effort.

The urgency of the grasshopper-control problem in the Western States required prompt action in providing equipment to meet the emergency. The new type of bait developed for this purpose required new machinery for spreading it. Special equipment using air as the dispersing medium was designed and installed in a DC–3 plane, which has consistently baited more than 20,000 acres per day.

The threat of the golden nematode to the potato industry now requires extensive annual soil examinations to determine the location and possible spread of this pest. A machine for washing soil samples to recover nematode cysts has been developed, which is expected to reduce by 70 percent the labor now required for manual processing.

Machines were also developed or modified for spraying insecticides from aircraft, for spreading dry grasshopper bait from trucks, and for controlling leafhoppers with truck-borne mist blowers.

The engineers in the Bureau of Plant Industry, Soils, and Agricultural Engineering have cooperated in these undertakings.

IMPORTED BEETLES CONTROL KLAMATH WEED ON WEST COAST

Early colonies of beetles imported from Australia have nearly eliminated the Klamath weed at many points of release in California, and the cleared areas are rapidly increasing in size. This weed crowds out grass on range, and animals forced to eat it for lack of better forage become sickly and underweight. Several years ago two species of *Chrysolina* beetles were found by Australian scientists to feed exclusively on this weed, known there as St. Johnswort, and were imported to that country from Europe to keep it under control. The Bureau in cooperation with the University of California undertook to adapt the beetles to conditions on this continent, and colonies were released in patches of the weed. During 1947–48 they had multiplied so that it was possible to release more than half a million beetles in California. Large numbers were also released in Oregon, Washington, Idaho, and Montana, in cooperation with the State agricultural experiment stations. A program for colonizing the beetles in the national forests of these States, in cooperation with the Forest Service, is now under way.

HONEY BEES AND OTHER POLLINATING INSECTS

Lack of Pollination a Serious Threat to Seed Production

Seed production in this country is threatened with a serious lack of insect pollinators. Wild pollinating insects have virtually disappeared in many localities following the use of the new insecticides or other modern agricultural practices that destroy their nesting places. Honey bees could easily be substituted for wild bees, but an alarming number of beekeepers are giving up their colonies because the price they receive for their honey is below the cost of production. They have little incentive to provide bees for the benefit of legume-seed producers and other farmers in the pollination of crops. There is already an acute shortage of legume seeds, particularly of the improved varieties. Unless the producers of these crops realize their dependence on bees and make arrangements to recompense beekeepers for the services of their colonies, the shortage can be expected to continue.

Honey Bees Prodigiously Active as Clover Pollinators

The value of honey bees in the pollination of clovers was demonstrated in Ohio by counts of their visits to the flowers. On alsike clover there were 380,000,000 bee visits on a normal stand of 450,000,000 florets per acre, mammoth red clover had 152,000,000 visits on a stand of 300,000,000 florets, and red clover 312,000,000 visits on 216,000,000 florets per acre. Honey bees on alsike clover visited 27 florets, on mammoth red clover 8 florets, and on red clover 10.5 florets per minute.

On 4 plots of red clover that were caged to exclude pollinating insects the average number of seeds per head ranged from 0.02 to 0.19, whereas on 15 plots on which honey bees were caged for pollinating purposes the range was 45.4 to 70.3 seeds per head.

Crops Compete for Bees

The pollination problem is complicated by a severe competition between various crops for the visits of bees. The competition between fields of alsike and white clover close to each other and between fields of the same clover is illustrated by the following numbers of bees per acre estimated from any one count:

Location:	*Alsike clover*	*White clover*
1	1,945	2,420 and 968 (2 fields)
2	3,194 and 1,936 (2 fields)	3,582
3	1,774	2,742

A field of red clover had but 1,210 bees per acre when competing against Hubam sweetclover, which had 21,780 bees, while heartsease nearby had 13,068 bees per acre.

The importance of plant competition in determining whether or not colonies of bees brought into a field will gather pollen from a given plant was indicated in an experiment in which all plant competitors of alfalfa were removed. Roadside weeds within a mile of five colonies were sprayed with 2,4-D. Although alfalfa was abundant, gumweed was the principal pollen collected by the bees before the spraying and continued to be even though the gumweed plants nearby had been killed. After the spraying the bees evidently extended their flight range to find new sources of gumweed rather than collect pollen from the alfalfa that was closer to the hives.

Bees may gather pollen readily from a kind of plant grown in one locality but not when it is grown in another locality. In Utah, for example, honey bees gathered little pollen from alfalfa grown in Cache Valley but collected it readily from alfalfa at Delta. Partial chemical analyses showed the ash content of pollen from Delta to be more than twice that of pollen from Cache Valley (2.50 versus 1.16 percent).

Of 65 species of wild bees that have been taken on alfalfa in other parts of the country, only 27 appear to contribute in an important degree to the pollination of alfalfa in Utah, although all 65 species have been collected in this State or in southern Idaho. *Halictus ligatus* Say was found on alfalfa in Utah for the first time in 1948.

Different species of wild bees seem to favor different crops. In Oregon the species of bumble bees that visited red clover were not found on Ladino clover. The bumble bees common on red clover belonged to only 4 or 5 species out of about 30 found in the State. In one area surrounded by rocky hills, bumble bees were as abundant as honey bees on Ladino clover, whereas in more intensely cultivated areas no bumble bees were found on this clover.

Wild Pollinating Insects Reared in Artificial Nests

Although the importance of the bumble bee and other wild pollinating insects has long been recognized, little has been done to rear and use them under controlled conditions. Experiments with bumble bees have given the most promise thus far. Of 54 artificial nests set out to attract bumble bee queens, 18 were found and accepted by young queens. In six of the accepted nests, males and new queens were produced. Colonies of *Bombus huntii* Greene were the largest. In the most populous of these nests 455 worker and male cells plus 156 queen cells were found at the end of the season.

Shade, concealment, and good drainage appear to be favorable factors for nest location. It is not necessary to place artificial nests underground, even for species that usually nest there. Attempts to induce *Megachile* bees to nest in holes drilled in wooden slabs were unsuccessful, as were attempts to transplant *Nomia melanderi* Ckll. into an artificial soil environment.

Hybrid Queens Distributed for Testing

Now that the artificial insemination of honey bee queens is proving satisfactory, beekeepers are showing much interest in the possibility of having hybrid bees that will prove as valuable to them as hybrid corn has proved to corn growers. This interest was greatly stimulated during the year when the Bureau, in cooperation with the Honey Bee Improvement Cooperative Association, began rearing and distributing hybrid queens for testing purposes. About 1,200 queens representing crosses of selected lines were distributed to beekeepers in various parts of the country. The program for 1949 called for the distribution of about 2,500 queens, to be furnished in lots of not less than 25 to any one beekeeper at a price above the market and with the provision that the Government be furnished certain reports of their performance. Such queens are being reared and mated naturally at an isolated mating station on Kelley's Island in Lake Erie.

New Insecticides Kill Only Field Bees

The bees that actually visit the dusted field are the only members of a honey bee colony that are affected by certain new insecticides applied for the control of insect pests. In studies to determine the effect of some of the new insecticides when applied for insect control, the only bees killed were those visiting the field within 2 days after the application. Parathion killed 40 percent of the visitors, DDT 28 percent, and chlordane 23 percent. Toxaphene killed only 8 and

2 percent in the two tests. Two-thirds of the bees killed by parathion died in the apiary, whereas two-thirds of the deaths from chlordane and most of those from DDT and toxaphene occurred in the field.

A decrease in the number of bees visiting an alfalfa field was noted after the use of DDT, chlordane, or parathion. Mortality accounted largely for this decrease in fields dusted with chlordane or parathion, but where DDT was used a slow repellency seemed to exist, which limited the number of deaths by reducing the number of visitors to the field.

Bees poisoned by chlordane or benzene hexachloride became sluggish and quiet with occasional spasms, similar to their normal response to low temperatures. In contrast, bees poisoned by DDT showed characteristic immediate tremors and greatly increased activity followed by paralysis. Death from DDT came more quickly than from the other two insecticides.

The lethal contact dosage of DDT per bee was found to be about 30 to 48 microgams and that of chlordane about 6 to 10 micrograms.

In cage tests with different concentrations of DDT the mortality depended on the amount of DDT present per bee. A decline in mortality was observed when the temperature was above 80° F., the temperature range tested being 74.5° to 85°. There seemed to be some tendency for the mortality to decline also with the humidity, in the range 61 to 92.5 percent, although this was not clearly established.

Spraying colonies with chlordane did not kill all the bees. In one test, while a red clover field in bloom was being treated for grasshopper control, chlordane was sprayed freely over the hives of three small colonies. Some bees were on the outside of the hive at the time. Nearly all the bees were affected and many died, but the colonies survived in a weakened condition. Two bumble bees collected in the treated area and caged on the day after the spraying died within 3 days, but a third lived more than 17 days. Caged solitary bees died the day after they were collected.

Nomia melanderi, a wild bee pollinator of alfalfa, was found to be affected by DDT applied while alfalfa was in bloom. A 3-percent dust was applied early in the morning at 20 pounds per acre. More than half the female bees nesting in the area visited the alfalfa on the same day. Although the dust seemed to be moderately repellent for a few hours, more than 2 percent of the bees nesting in sample areas were found dead at their nest entrances and about 15 percent of the nests became inactive, apparently as a result of the treatment. Spraying or dusting for insect control while crops are in bloom should be avoided wherever possible. If necessary to save the crop, insecticides should be applied at a time of day when the bees are inactive.

Honey Bees Bred for Resistance to American Foulbrood

The progeny of two of the lines of honey bees showing marked resistance to American foulbrood in 1947 were 100 percent resistant to this disease in 1948. One line, however, showed considerable lack of

colony strength. This line had also been entirely resistant in 1947; the other had been 86 percent resistant, although all infected colonies had recovered by the end of the season. This is the twelfth season that these two lines have been bred and tested in successive generations. Another line that had been tested similarly and showed 100 percent resistance in 1947 had become so weakened, apparently by inbreeding, that tests with it were discontinued in 1948.

Sulfathiazole for Treating American Foulbrood in Experimental Stage

Six colonies infected experimentally with American foulbrood in 1946, and treated with sulfathiazole fed in sugar sirup in 1946 and 1947, remained healthy in 1948 until July 21, when a slight recurrence of the disease was noted in two of them.

Plastic Package-Bee Containers Withstand Shipping Tests

Six experimental transcontinental shipments of package bees in the new plastic containers mentioned in last year's report were made from Davis, Calif., to Beltsville, Md., in cooperation with the United Air Lines. Two of the shipments made the return trip to Davis. All the bees shipped with food in the containers survived well. One such package crossed the continent three times with but 5 percent mortality. A special food consisting of a sugar-sirup-agar jelly was suspended in a cloth bag. Some bees were shipped without food, but they died. A few of the containers were damaged. These plastic containers are smaller, lighter, and probably longer lasting than containers of wood and screening now in use, but thus far they have been more costly to assemble and crate and less convenient to handle, particularly to remove hitchhiking bees.

CONTROL OF PLANT DISEASES

White-Pine Blister Rust

Improved methods aid ribes removal

The control of white-pine blister rust was aided by increased use of chemicals, the one-man eradication method, and contract procedure for the removal of ribes. Chemical eradication of ribes is speeding up the work on areas where hand grubbing is difficult. Methods of application are constantly being improved. Power equipment is used successfully where it is feasible to broadcast large volumes of low-cost sprays. A special back-pack sprayer has given good results in areas where selective treatment with small amounts of concentrated solution is more practicable.

The ribes-infested area treated with chemicals in 1948 was about twice that treated the previous year. In the sugar-pine section of California about 3,000,000 *Ribes roezli* plants growing on 1,242 acres were destroyed by spraying with 2,4-D. In the western white-pine

region of Idaho and western Montana, *R. petiolare*, *R. lacustre*, and *R. viscosissimum* growing on 1,858 acres were sprayed with 2,4-D, 2,4,5-T, or ammonium sulfamate. Several species of ribes more or less resistant to 2,4-D were killed with 2,4,5-T. The work of treating large *R. cereum* and *R. nevadense* bushes was done more rapidly by applying the ester of 2,4-D in a light, penetrating oil to the basal parts of the stems.

Wider use was made of the one-man method of ribes removal in all regions. This is a radical change from former crew methods in that each man works alone covering a strip about 2½ chains wide. This method fixes individual responsibility for the amount of ground covered and the thoroughness of ribes removal. Poor work is quickly discovered and corrected. The method has resulted in greater production and higher efficiency.

Ribes eradication work conducted under contract to private individuals on designated areas was expanded somewhat in the western regions. All participating agencies issued 107 contracts for ribes eradication in the sugar-pine region. Ribes bushes were removed from 15,000 acres at an average cost of $4.86 an acre. In the western white-pine region 11 contracts were issued by the Forest Service. The work accomplished by this method is better in both quality and quantity than that done by seasonal crews. The use of the method is now limited by lack of qualified bidders. As the number of bidders increases, bid prices will be lower and greater use will be made of this method.

Two small camps of 12 to 15 workers, a cook, and a superintendent were operated in rework areas in the western white-pine region. The small camp has several advantages over the 30- to 60-man camps for work in the smaller and more scattered rework areas. Morale and employee relations are better, and supervision of field work is not handicapped by problems in camp administration. In these camps there was no labor turnover in 1948. The installation of such camps is less costly, and they can be more strategically located than larger camps. All these advantages contribute to greater production per worker and consequent lower costs.

Ribes bushes removed from 1,679,000 acres

Federal and State cooperating agencies removed over 20,500,000 ribes bushes from 1,679,000 acres during the calendar year 1948. About one-third of the work represented initial removal of ribes. The remainder was the reworking of partially protected areas to maintain control of blister rust and further the establishment of ribes-free conditions. Control of the rust became fully established on more than 743,000 acres, and this acreage was placed on a maintenance status.

Field operations were conducted on a smaller scale than in the previous year. Labor was more plentiful and of better quality. A total of 188,800 effective man-days were used. At the peak of the season 4,980 persons were employed by the Federal, State, and private agencies cooperating in ribes eradication, and 90 camps were operated in forested areas.

The blister rust control area comprises 27,500,000 acres. Over 23,000,000 acres have been worked once, and 8,000,000 acres twice. Additional workings have been given to about 2,000,000 acres. About 12,738,000 acres, or 46 percent of the control area, are on maintenance, 4,000,000 acres are unworked, and 10,686,000 acres require additional rework before they will reach a maintenance status.

The environs of 12 nurseries containing over 65,000,000 white pines for forest planting were reworked during the year, and 2,067 ribes bushes were removed from 6,153 acres. In addition, 68,702 infested white pines, mostly in plantations, were saved by the cutting off of diseased parts. Cooperating State and local agencies provided funds and services amounting to $673,000 for removal of ribes on State and private lands.

Rust spread in southern Appalachians

Blister rust was found for the first time on ribes in eight counties in North Carolina and four in Tennessee. The range of the disease was thus extended about 50 miles southward and approximately 125 miles westward in the southern Appalachians. The disease was reported on white pines for the first time from one additional county each in West Virginia, Wisconsin, and Minnesota. It is now present throughout most of the range of the commercial white-pine forests. In the sugar-pine region the spread of the rust has been retarded by elimination of infection centers. The diseased trees are destroyed and the ribes within infecting range of the pines are removed.

Ribes sprayed with 2,4-D formulations by helicopter

The first tests of the helicopter for spraying ribes with 2,4-D were made on the Sierra National Forest in California. A Bell model 47B-3 equipped with a 44-nozzle boom was flown within 30 feet of the ground at land elevations of 5,200 to 6,000 feet. The maximum spray load carried was 20 gallons. In 54 flights 18 plots, totaling about 38 acres, were sprayed with 575 gallons of various formulations and dosages at ground speeds of about 30 miles per hour. Observations 6 weeks after treatment showed that the 2,4,-D ester in Diesel oil was generally more toxic to ribes and associated brush than the water solutions of the esters or salts. Significant damage to *Ribes roezli* and *R. nevadense* and other susceptible plants was caused by 16 ounces or more of 2,4-D acid per acre. Damage to ribes was spotty wherever these plants were screened by other vegetation. In general, the apparent kill of ribes and susceptible brush is closely related to the density of the spray deposit. Most uniform coverage was obtained on plots where slope and ground obstructions permitted spraying from opposite directions. Final results of the spray tests will be determined when the plots are checked during the 1949 growing season.

Survey shows rust losses in western pine stands

A survey was carried on to determine the white-pine stocking and the damage from blister rust in reproduction and pole-size stands of western white pine in the Inland Empire. About 1,000 miles of strip were run on the survey. The results showed that the original stocking in these stands had been reduced by 25 percent from blister rust, leav-

ing potential timber volumes at 120 years averaging 15,750 board feet of white pine per acre. On areas where control has been established, the future yield has been estimated at 5 billion board feet. On areas partially protected an additional yield of 7 billion board feet depends upon completion of ribes eradication to prevent further losses. Each year that control work is delayed approximately 3 percent of the stand is becoming fatally infected. Rust infection occurring through 1937 is responsible for a large part of the damage expected in pole-size white-pine timber, although where ribes were present, considerable new damaging infection occurred in 1941. The amount of damaging infection in pole stands parallels that in reproduction under similar conditions.

Barberry Eradication To Control Stem Rust

New and uncommon races of rust found on barberry

The production and perpetuation of races of the stem rust fungus on barberry bushes was again demonstrated in 1948. A different race of the disease was found for every 3½ isolations made from stem rust on barberry bushes. In comparison, a different race was identified for every 74 isolations made from rust on grains and grasses. Five unusual races and two new ones were identified from the disease on barberry. Outside of barberry-infested areas only races 38, 17, and 56 of the rust fungus of wheat were important. They made up 93 percent of more than 1,700 isolations.

Race 15 of the wheat stem rust was isolated from infected barberry leaves obtained from Pennsylvania, Virginia, Ohio, Michigan, and Illinois. Race 15B, a biotype of race 15, was also identified from the Pennsylvania collections. This is a virulent race, which can attack all the commercially grown wheats. In one local stem rust spread from barberry to wheat in Pennsylvania, 19 races of the disease were obtained from 8 collections. From another spread 25 races and biotypes were obtained from 20 collections. Race 11 was the most virulent found in this group. Some others are dangerous because they can attack some of the parent varieties used in the wheat-breeding program. Race 7 was found on oats growing adjacent to barberry in New York. This race attacks the newer oat varieties now in commercial production, but it is not yet abundant or widespread.

Stem rust light in 1948

Stem rust was not of general economic importance in 1948 in the States participating in barberry eradication. Destructive local epidemics starting on barberries occurred in Pennsylvania, Virginia, and West Virginia. There was also heavy stem rust on wheat in limited areas in southeastern Illinois and southwestern Indiana. Indications are that spores responsible for this infection came from farther south, where the disease overwintered. Stem rust appeared late in the season in the durum areas of the Dakotas and in the Palouse district of Washington. Losses of wheat, oats, barley, and rye from stem rust in the States participating in barberry eradication have gradually decreased as control work has progressed, as shown in figure 1.

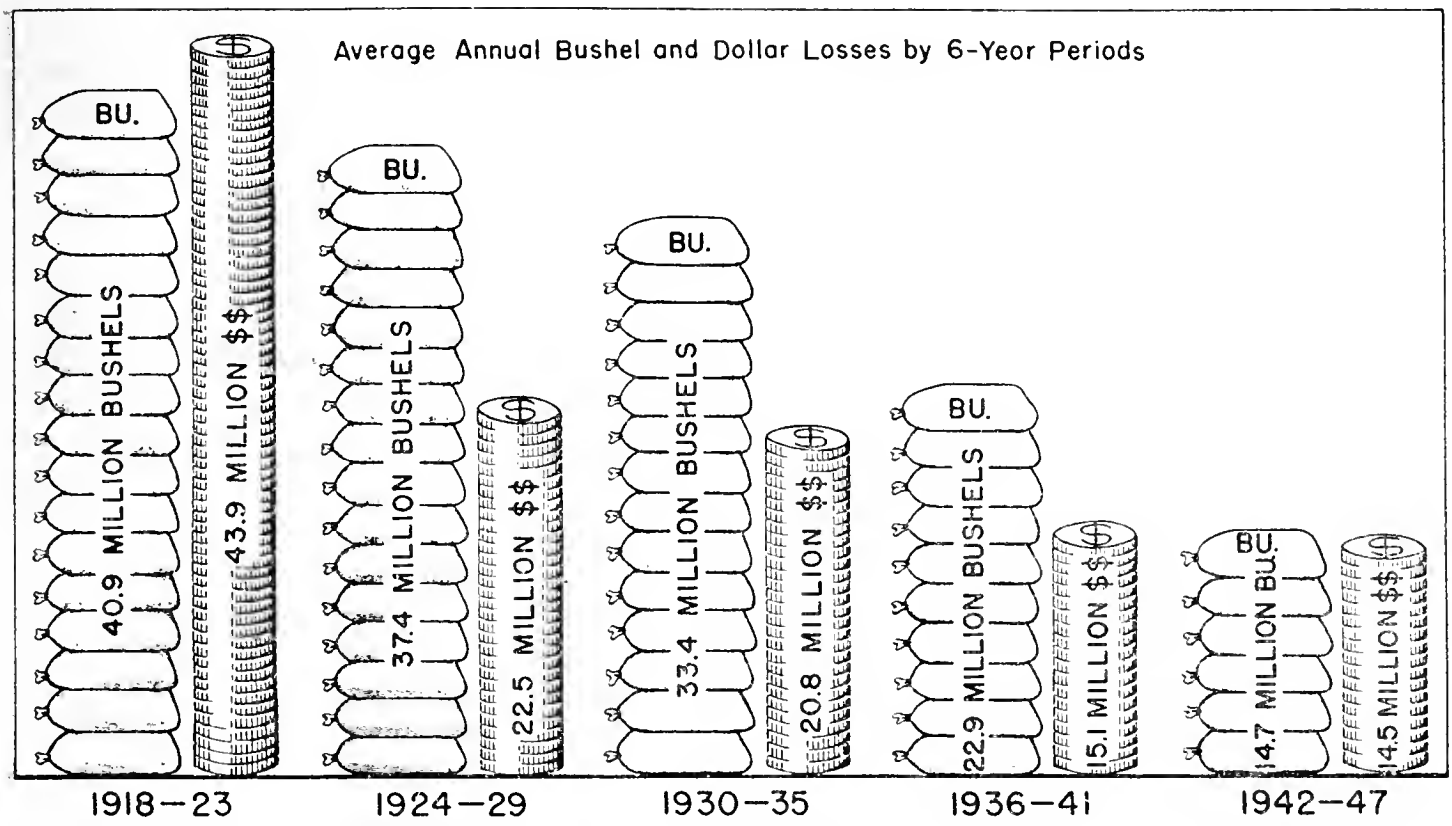

FIGURE 1.—Reduction in losses of wheat, oats, barley, and rye due to stem rust as control work has progressed.

Regulation of barberry planting stock strengthened

Both foreign and domestic regulations controlling the movement of barberry plants have been strengthened to prevent the distribution of off-type susceptible stock. In recent years increasing numbers of susceptible *Berberis thunbergii* hybrids were located in nurseries and landscape plantings. Nurserymen were suffering losses from impure stock, and four-fifths of the area in the eradication States that had been cleared of rust-spreading barberries was in danger of becoming reinfested with such bushes.

In one nursery a vigorous red-leafed plant was taken from a block of Japanese barberry, and a large number of plants of this so-called improved strain were propagated and sold without the knowledge that it was a susceptible hybrid. This plant was used as a source of cuttings, and in 1948 the nursery had 2,700 vegetatively propagated plants and 10,000 cuttings. Some of the bushes were infected with stem rust, and the disease had spread to wild grasses nearby. The nurseryman had assumed that the original plant was immune to stem rust because it had been selected from the resistant Japanese barberry stock. All the stock was condemned and destroyed, but some of it had been sold to nurseries and individuals in 19 States before its discovery.

Nurserymen are encouraged to grow only rust-resistant barberries for the trade and to remove all susceptible plants within and around their nurseries to prevent hybridization. They are responding favorably and cooperatively in this work.

During the year barberry bushes were removed from areas totaling 25,390 square miles, of which 18,271 square miles was rework and 7,119 initial work. Nearly 13,000,000 barberry bushes were destroyed on 5,523 new and 1,757 reinfested properties in 225 counties.

Chemicals aid removal of barberry bushes

Ammonium sulfamate and 2,4-D applied to cut surfaces of barberry canes helped to speed up the eradication of planted bushes. Previously bushes found in cities and towns were dug. The use of these chemicals has greatly expedited the work in the city of Spokane and the Spokane Valley in Washington. Tentative figures indicate a saving of about 10,000 man-hours of labor over the old digging methods.

Foliage spray of 2,4-D is now being used on the native barberry in southwestern Colorado. This chemical is used during the growing period of the plants. The cost of treatment is approximately 80 percent under the cost of treating with chlorate or common salt. Tests of chemicals are being continued in the hope of finding one that can be used effectively at any time of year.

Barberry varieties tested for susceptibility to stem rust

Fifty-three species and varieties of barberry were tested during the year to determine whether they were resistant to stem rust. Of these, 30 have been tentatively classed as resistant and 9 as susceptible. The others require further testing. A large-scale test of the Sheridan barberry was carried out because morphological characters of the plant indicated hybrid origin. About 120 seedings of this variety were inoculated one or more times, and 4 of them were susceptible to stem rust.

Dutch Elm Disease

The Dutch elm disease fungus was found in 3,093 specimens from 11 States and the District of Columbia during the year. Twelve diseased trees were found scattered about the District of Columbia, and 12 more along the Potomac River above Washington. Five infected trees were found near Baltimore, Md., after 7 years of no known Dutch elm disease there. One diseased tree was found in western Pennsylvania, 200 miles west of previously known infections. Thirty-two infected elms were found in Vermont, whereas only 2 were found during the previous year. The disease was found for the first time in 44 towns in Massachusetts, some of them near the New Hampshire border.

The Bureau assisted in the organization of scouting and control work by State agencies in Maine, New Hampshire, and Massachusetts, and by cooperative civic and municipal groups in Cleveland, Akron, and Youngstown, Ohio. A comprehensive statement on Dutch elm disease control measures that might be employed by elm owners, arborists, and public agencies was issued jointly by Federal and State authorities. The adequacy of the spraying to control Dutch elm disease by four municipalities—Springfield, Mass., Greenwich, Conn., and Akron and Cleveland, Ohio—was tested by exposing samples from their sprayed elms to bark beetles. The resulting feeding indicated that insufficient DDT had been applied.

In Morristown and Princeton, N. J., late-summer and early-spring applications of DDT were again made to about 3,700 elms in several plots established in 1946 and 1947 to test the practicability of using DDT to prevent bark feeding and thereby prevent Dutch elm disease

infection on healthy elms. Mist blowers, hydraulic sprayers, and a helicopter were used in other areas to test methods and DDT formulations. Twig samples taken from these sprayed elms were exposed to bark beetles, and examined to determine the adequacy of initial deposits and residual DDT for preventing bark beetle feeding. Quantitative analyses of the DDT were made on the same samples. An early-spring application, with a hydraulic sprayer, of a 2-percent DDT emulsion followed by a 1-percent DDT emulsion gave consistently good results.

Continued attention was given to possible injury to elms and other trees, to turf grasses, and to birds, fish, and other animals caused by the application of large amounts of DDT and its solvents. Spider mites became abundant on the sprayed elms in the large test plot, apparently as a result of the spraying, and steps were taken to control this secondary pest.

Inspection for Peach Diseases Protects Industry

Inspection of nurseries to prevent spread of the phony peach and peach mosaic diseases was continued during 1949 in cooperation with State agencies.

In 14 States 2,300,000 trees in 239 nurseries and 415,000 orchard trees within a 1-mile radius of these nurseries were examined, as well as 35 budwood sources with their 1-mile surroundings comprising 56,800 trees. Beyond regulated areas an additional 188 nurseries producing 7,936,000 nursery stock trees and the 239,300 orchard trees in their environs were examined as a precautionary measure.

In the peach mosaic area State certification was withheld from 35 nurseries—from 2 because of disease on the nursery premises and from 33 small nurseries because diseased trees remained on the property after May 15. Four budwood sources were refused certification because of local mosaic conditions. In the phony peach area one nursery failed to qualify.

During the calendar year 1948 nearly 40,000 orchards containing nearly 9,000,000 trees were examined in 186 counties in 15 States. Approximately 68,500 diseased trees were found in these orchards, and more than 90 percent of them were promptly removed.

This program, begun in 1936, has prevented spread of these diseases through nursery-stock channels. It has lowered the general orchard incidence of peach mosaic from 45,063 infected trees recorded in 1936 to only 7,447 trees in 1948. The work has also greatly reduced the phony disease as a serious orchard problem in all but two States, Alabama and Georgia, where special conditions appear to favor this infection.

Resurvey Fails To Reveal Citrus Canker in Texas

Reinspection of all citrus trees in Texas on or near properties upon which citrus canker has been found since 1920 and the examination of *Poncirus trifoliata* hedges throughout eastern Texas were continued through April 1949. Since this resurvey was begun in September 1947, crews have examined over 4,000,000 citrus trees, escaped plants,

and seedlings on 23,730 properties in Texas and in adjacent Miller County in Arkansas. Not a single case of citrus canker was detected. This favorable outcome strengthens the hope that citrus canker eradication may now have been actually accomplished in Texas.

INSECT IDENTIFICATION AND CLASSIFICATION IMPORTANT AIDS TO CONTROL PROGRAMS

Taxonomists contributed to the over-all insect-control program by furnishing upwards of 50,000 identifications to workers in the Bureau and in numerous other agencies, as well as to individuals. Important among such identifications in 1949 were large numbers required in connection with projects for control of the oriental fruit fly in Hawaii and of the white-fringed beetle in the southeastern part of the United States, with surveys to determine the occurrence of leafhopper and aphid vectors of diseases of peaches and potatoes, and to obtain information on insects of medical importance in Alaska.

A noteworthy project in basic research essential to sound insect classification has been conducted in cooperation with the British Museum during the last 2 years. It comprised a thorough study of the enormous Meyrick collection of Lepidoptera, which includes numerous kinds of minute moths that are of much economic importance. The identity of most of these forms has long been obscure and could be determined only by restudy of the types and redefinition of all the species. This research was performed by a specialist of this Bureau, sent to London for the purpose, and the results will be published by the British Museum.

Another large research project that has just been completed after intermittent work for more than 10 years is a classification of North American leafhoppers. The results of this study will be of great aid in identifying the numerous leafhoppers that are important vectors of plant diseases.

IN-TRANSIT INSPECTION

In the enforcement of Federal domestic plant quarantines, transit inspectors were stationed during all or part of the year at 15 terminal points through which regulated commodities moved in heavy volume by freight, express, or parcel post. These inspectors examined about 1,400,000 shipments and found 1,343 of them to be moving contrary to the regulations of one or another of the quarantines regulating interstate movement of plant and other host material. These violations involved seven of the eight Federal domestic quarantines.

INSPECTION SERVICE IN DISTRICT OF COLUMBIA

Inspection in the District of Columbia from June 1, 1948, to May 31, 1949, covered 37,521 in-bound shipments of plants. Of this number 25 were found to lack the required State certification, and 2 were destroyed or returned to the sender because of pests on them. During the same period 1,027 lots of plants were certified for shipment from the District to 44 States, the Canal Zone, Puerto Rico, and the American Zone in Italy.

FOREIGN PLANT QUARANTINE ACTIVITIES

Further safeguards were put into effect during 1949 to strengthen our defenses against the invasion of injurious plant pests. The regulations governing the importation of nursery stock, plants, and seeds were revised to give more adequate protection against the introduction of such pests with plant propagating material.

The revision provides for the prohibition of additional specific plant material known to be subject to infestation or infection by certain insect pests or plant diseases in the country of origin, and for the growing of certain material under post-entry quarantine long enough to determine its apparent freedom from infestation or infection with plant pests not discernible by port-of-entry inspection. The preflight clearance of aircraft destined to the mainland, which has proved so effective in Hawaii, was extended to domestic planes flying from Puerto Rico direct to the continental United States. Other Federal agencies, particularly the Bureau of Customs, the Immigration and Naturalization Service, the Public Health Service, and the Departments of the Navy and the Air Force contributed materially to the program.

Carriers and Products Inspected

Plant quarantine activities at maritime ports of entry continued on a high level during the year. Prohibited plant material was found on 25 percent of the 43,000 vessels inspected. This material originated in countries throughout the world, and much of it was found to harbor destructive plant pests. Although most of the arriving ships came directly from foreign ports, there were 676 vessels from Hawaii, 222 of which bore prohibited material, and 511 vessels from Puerto Rico, 71 of which carried unauthorized material.

The prevention of the entry and spread of injurious plant pests with airborne traffic continued to be one of the most serious problems in the plant quarantine program. During the year more than 60,500 airplanes were inspected at 51 ports of entry, including 3,679 arrivals from the mainland inspected in Hawaii. Approximately one out of every four planes inspected carried prohibited plant material which, if not intercepted, could have been transported to almost any point in the United States within a matter of hours.

Importations of restricted plant materials under permit—particularly fruits, vegetables, cotton and cotton products, fibers, cereals, and plant propagating material—also continued to be heavy in 1949. More than 186,330,000 crates, boxes, bales, bushels, and other units were inspected and safeguarded when necessary to eliminate the risk of introduction of injurious insects and plant diseases. In addition, millions of small lots of restricted plant material entered over the Mexican border which required inspection but were not recorded. Large quantities of fruits were imported from South Africa and Argentina on the basis of refrigeration treatment, and there was an increased interest in the importation of agricultural material by air,

particularly of fruits and vegetables from Mexico and other Latin-American countries.

Not only are all planes inspected upon arrival in Hawaii, but also all planes preparing to depart for the mainland. Airplanes are also treated with an aerosol containing DDT. The necessity for this procedure, especially for planes destined to the mainland, was repeatedly demonstrated during the past year by the finding of living adults of the oriental fruit fly in planes preparing to depart for the continental United States. Of 4,051 planes given preflight inspection and treatment prior to departure for the mainland, 1,665 would have transported unauthorized plant material had it not been removed at the point of origin.

Over 34,000 automobile trunks and pieces of baggage, more than twice the number in 1948, were inspected and sealed prior to departure for the continent on surface vessels. The discovery that the oriental fruit fly occasionally attacks blooms of Vanda orchids made it necessary to require treatment of the blooms prior to shipment. Almost 266,000 packages of cut flowers and leis were examined, 3,125 of which were rejected and 35,500 permitted to move after treatment. Shipments of fruits and vegetables to the mainland totaled 860, of which 174 required treatment before being certified.

During the last quarter of the year preflight clearance of airplanes destined to the mainland was also started in Puerto Rico. Of the 556 planes inspected during this brief period 339 carried unauthorized plant material. A total of 911 shipments of fruits and vegetables were certified for movement from Puerto Rico to the continental United States.

Traffic across the Mexican border continued to increase; more than 7.5 million vehicles and 2.5 million pieces of baggage were inspected during the year. About 3,300 pullman and passenger coaches from Mexico were also inspected at border ports. The safeguarding of traffic from Mexico is especially important at this time because of heavy infestations of the citrus blackfly in that country. The Valles area, where infestation is exceedingly heavy, is only a few hours' drive over paved highways from the important citrus-production area of the Lower Rio Grande Valley.

The number of freight cars inspected and entered during the year totaled 68,013, a decrease of 8 percent from the previous year. It was necessary to fumigate 5,467 of these cars before permitting them to enter the United States. During the year a new railway was put into operation connecting the mainland of Mexico with Baja California, which is believed to be free from several important pests that occur elsewhere in Mexico. To safeguard against the movement of these pests into this territory, where they would have an excellent opportunity to migrate to the United States, a cooperative arrangement has been worked out with the Mexican Department of Agriculture whereby bus, ocean, air, and rail traffic to Baja California from the interior of Mexico is inspected.

More than 2,240,000 parcel-post packages were inspected during the year, and 2,800 were found to contain prohibited plant material. For various reasons it was necessary to divert 9,500 packages to other ports for handling, and 6,900 were released under permit after inspection. Among the serious pests intercepted in foreign mails during the year was the golden nematode, found in soil attached to the roots of shamrocks from Ireland. In Hawaii over 365,000 parcel-post packages were examined prior to dispatch to the mainland, 76,000 of which were opened for inspection. More than 8,000 of the 105,000 parcel-post packages examined in Puerto Rico before movement to the continent were opened for inspection. The problem of safeguarding Puerto Rican mail was increased when the Post Office Department began dispatching domestic parcel post by air on September 1, 1918.

During the year 670 lots of plants, seeds, and other propagating materials were imported by the Department of Agriculture for scientific and experimental purposes. These plant materials were examined and treated, if necessary, at the Washington, D. C., inspection house. When pest conditions so warranted, the plants were grown in detention and inspected regularly to determine whether pests that were not detectable at the time of original inspection had made their appearance. Final inspection prior to release was made of 3,132 lots of exotic plants grown by the Department under quarantine conditions.

Plant materials being grown at the plant introduction and propagating gardens of the Bureau of Plant Industry, Soils, and Agricultural Engineering were also inspected regularly for the presence of pests. Material distributed from the gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau, while inspections at Chico, Calif., were made jointly by Bureau and State officials, and from the District of Columbia, Beltsville, Md., and Savannah, Ga., stations by Bureau inspectors. During the year 102,000 plants, 5,000 bud-sticks and cuttings, 133,000 roots and tubers, and 400 lots of seeds were inspected prior to shipment from these gardens.

Plants and Pests Intercepted

The 135,300 interceptions of prohibited or restricted plants and plant products made in 1949 represented a decrease of about 1 percent from the preceding year. These materials were taken from baggage (89,900), from cargo (3,800), from mail (4,300), from quarters (14,300), and from stores (23,000). Additional interceptions of plant material were made by customs officers at Mexican and Canadian border ports, where the traffic does not warrant the services of a plant quarantine inspector.

Interceptions of insects and plant diseases during the year totaled 22,400. They included 9,370 lots of insects and 2,240 of plant diseases in agricultural material imported for consumption and 5,770 lots of insects and 1,300 of diseases in material entered for propagation. The

remainder were taken from material not offered for entry and from ships' stores and quarters. These forms included only the more important pests and pathogens intercepted. Thousands of interceptions of insects and plant diseases of little or no economic importance were made in the course of inspection, but no record was kept of them.

A total of 4,650 lots of insects and plant diseases were intercepted from airplanes in 1949, most of which were found with host-plant materials, although a few arrived as stowaways. Among the more important insects intercepted were the citrus blackfly; the oriental, olive, Mediterranean, Mexican, West Indian, and five other species of fruit flies; the pink bollworm; and the mango weevil. Disease organisms intercepted included the Sigatoka disease of bananas, sweet orange scab of citrus, lima bean scab, the black spot of citrus, the spot anthracnose of apple and pear, and citrus canker. Interceptions of nematodes included the golden nematode of potatoes, as well as pests of peas and wheat.

Treatment of Imported Plant Material

Because of the pest risk involved, certain plants and plant products must be fumigated or otherwise treated as a condition of entry into the United States. In 1949 more than 500,000 bales of cotton lint, linters, and bagging; 40,000 pounds of cottonseed cake and meal; and 17,200 samples of cotton and linters were so treated. Other materials safeguarded by treatment included about 8,400 cases of fruits and vegetables; 47,500 containers of chestnuts, cipollini, and pigeonpeas; 36,200 bales of broomcorn; 2,585,300 units and 5,000 containers of plants, cuttings, bulbs, roots, and other propagating material; 48,700 pounds, 18,700 units, and 1,500 containers of seeds; and 21,500 lots of miscellaneous plant products.

Many shipments of salvaged military equipment, most of which was collected from beaches and swamps on islands of the Pacific where it had lain for months, arrived at mainland ports of entry. Examination of this material revealed the presence of living giant African snails in the cargoes of 10 ships—5 from the Philippine Islands, 4 from Saipan, and 1 from Guam. To prevent the introduction of this pest it was necessary to require the cleaning and fumigation, or other treatment, of 2,190 lots of such equipment and the vessels transporting the material. It was also necessary to treat 1,000 tons of soil ballast containing infested plant material.

Certification for Export

There was a marked increase in the demand for plant quarantine services in connection with the inspection and certification of plants and plant products for export during 1949. A total of 13,320 export certificates covering 4,432,000 containers of domestic plants and plant products were issued to meet the import requirements of foreign countries. This inspection and certification were performed at 39 ports and covered 103 commodities consigned to 104 foreign countries.

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Division of Grasshopper Control	Claude Wakeland
Division of Golden Nematode Control	H. L. Smith

[1] Succeeded by Ralph A. Sheals on Oct. 1, 1949.
[2] Died on Aug. 25, 1949, succeeded by Roy T. Richmond.

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